State of California
The Resources Agency
Department of Water Resources

SP-F3.1 TASK 2A, 3A REPORT FISH SPECIES COMPOSITION: LAKE OROVILLE, THERMALITO DIVERSION POOL, THERMALITO FOREBAY

Oroville Facilities Relicensing FERC Project No. 2100

JUNE 30, 2003

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REPORT SUMMARY

This study identifies the fish species composition in Lake Oroville, the Thermalito Diversion Pool, and the Thermalito Forebay, and represents tasks 2A and 3A of the SP-F3.1 study entitled, *SP-F3.1 Evaluation of Project Effects on Fish and Their Habitat within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area.*

Information from this study will be used to identify the potential impacts of the Oroville Facilities on these fishery resources, and in the analysis of the impact of the project's resident fisheries on upstream tributary fish, downstream special status fish, and in the development of a recreational fishery management plan and other potential protection, mitigation and enhancements (PM&Es) (resource actions) for the project. Related study plans that will use this study as a baseline include SP-F2, SP-F3.2, SP-F5/7, SP-F8, and SP-F15, as well as in the recreation analyses of SP-R4 and SP-R17.

A listing of the fish species is presented along with a general perspective as to the relative abundance of these species. In addition, the relationship of these fish species compositions to fishery management programs is also discussed.

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1.0 INTRODUCTION

This study identifies the fish species composition in Lake Oroville, Thermalito Diversion Pool, and Thermalito Forebay, and represents tasks 2A and 3A of the SP-F3.1 study entitled, *SP-F3.1 Evaluation of Project Effects on Fish and Their Habitat within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area.* Information from this study will be used to identify the potential impacts of the project on these fishery resources, and in the analysis of the impact of the Oroville Facilities' resident fisheries on upstream tributary fish, downstream special status fish, and in the development of a recreational fishery management plan and other potential protection, mitigation and enhancements (PM&Es) (resource actions) for the project.

1.1 STUDY AREA

The study area for this report is Lake Oroville, the Thermalito Diversion Pool, and the Thermalito Forebay.

1.2 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area (OWA), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational facilities. An overview of these facilities is provided on Figure 1.2-1. The Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet (maf) capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cfs and 5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam, four miles downstream of the Oroville Dam creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cubic feet per second (cfs) of water into the river.

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the 114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate 15,000 to 20,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the OWA.

The OWA comprises approximately 11,000-acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000 acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. California Department of Fish and Game's (DFG) habitat enhancement program includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

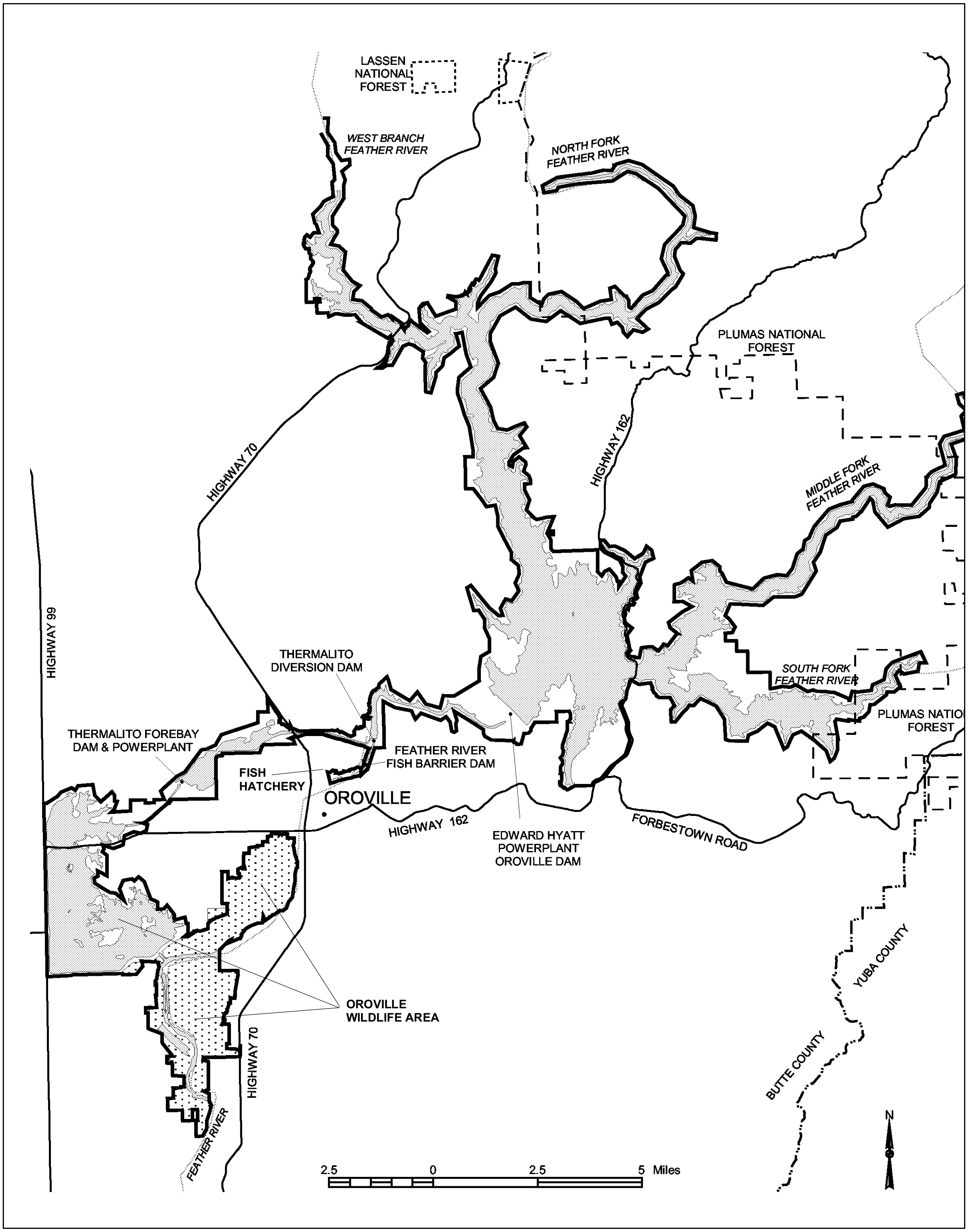

Figure 1.2-1. Oroville Facilities FERC Project Boundary

1.3 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning is conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet (af); however, this does not limit draw down of the reservoir below that level. If hydrology is drier than expected or requirements greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level (msl) in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

1.3.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled, “Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife,” sets criteria and objectives for flow and temperatures in the low flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

1.3.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that Oroville Facilities release a minimum of 600 cfs into the Feather River from the

Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

1.3.1.2 Temperature Requirements

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52°F for September, 51°F for October and November, 55°F for December through March, 51°F for April through May 15, 55°F for last half of May, 56°F for June 1-15, 60°F for June 16 through August 15, and 58°F for August 16-31. A temperature range of plus or minus 4°F is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

The National Marine Fisheries Service has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson's Riffle in the low-flow channel) from June 1 through September 30. This measure requires water temperatures less than or equal to 65°F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California ISO anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area (FRSA) contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65°F from approximately April through mid May, and 59°F during the remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

1.3.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 (July 2002) af are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.3.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.3.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 NEED FOR STUDY

This study identifies the fish species composition in Lake Oroville, Thermalito Diversion Pool, and Thermalito Forebay, and represents tasks 2A and 3A of the SP-F3.1 study entitled, *SP-F3.1 Evaluation of Project Effects on Fish and Their Habitat within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area.* This study plan is needed because on-going project operations affect water surface elevations, fish habitat, water temperature and other factors influencing warmwater and coldwater fish populations. Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the FERC Application for License for major hydropower projects, including a discussion of the fish, wildlife and botanical resources in the vicinity of the project. The discussion needs to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact for on-going and future operations of the project.

In addition, information from this study will be used in the analysis of the impact of the Oroville Facilities' resident fisheries on upstream tributary fish, downstream special status fish, and in the development of a recreational fishery management plan and other potential protection, mitigation and enhancements (PM&Es) (resource actions) for the project.

3.0 STUDY OBJECTIVE(S)

The objective of this study is to describe the fish species composition of Lake Oroville, Thermalito Diversion Pool and Thermalito Forebay using the existing information available, as specified in SP-F3.1 Tasks 2A and 3A. A listing of the fish species will be presented along with a general perspective as to the relative abundance of these species. This fish species composition will provide the baseline for impact analyses within SP-F3.1, and other study plans such as SP-F2, SP-F3.2, SP-F5/7, SP-F8, and SP-F15, as well as in the recreation analyses of SP-R4 and SP-R17.

In addition, this study analyzes the nature of the Lake Oroville data to determine if a fish species distribution can be identified.

4.0 METHODOLOGY

4.1 STUDY DESIGN

This current fish species composition for Lake Oroville, Thermalito Diversion Pool and Thermalito Forebay is based upon data collected from several different evaluations over the last decade, utilizing a variety of sampling methods and levels of intensity. This mix of data sources precludes its use for making population estimates, or detailed estimates of relative abundance, unless specifically noted in the report. As an example, carp were often observed in electrofishing surveys at Lake Oroville, though they were not a target species so they were excluded from regular capture and measurement. Hence their numbers would appear in the data far lower than catfish, a targeted species, even though carp are much more common. This data would not provide an accurate comparison of the abundance of these two species, however, accurate comparisons between catfish and black bass would be possible since no intended bias was practiced in the electrofishing capture of these species. Because of these inconsistencies, the relative abundance of the fish species in this report will be presented in general terms, using "Frequently Observed", "Infrequently observed", and "Uncommon." Any specific comparisons of relative abundance (e.g. percentage of black bass vs. catfish) that are in this report will be specifically noted.

Only fish species recorded in the last 10 years (since 1993) will be considered currently present, any recorded prior to this will be considered historic species that are no longer present. A separate list of these historic fish species will be presented, this is primarily related to fish that were stocked at one time but did not develop a self-sustaining population, and therefore disappeared from the fishery over time. This information was obtained from the DFG and DWR files on these waters.

As with most recreational fisheries, a significant amount of anecdotal, "unofficial" fish presence information also exists, this will be identified where presented in the report.

4.2 STUDY METHODOLOGY

4.2.1 Lake Oroville

The fish species composition for Lake Oroville was primarily based upon data collected as part of a DFG fishery study conducted during the 1990s. This data was used in the creation of a 1999 report titled, *Growth and Contribution to the Fishery of Chinook Salmon at Lake Oroville, California* (Appendix A). This study gathered most of its fish identification data through the use of boat electrofishing and an angler survey.

The boat electrofishing surveys used at least one Smith-Root SR-18 electrofishing boat per survey, and these surveys were conducted quarterly from August 1994 through June 1999, totaling 39 nights of sampling effort. The surveys targeted game fish, particularly black bass, in order to monitor their condition factors over time. Common non-game fish such as carp, wakasagi (smelt), and juvenile sunfish (e.g. bluegill) were often excluded from the sampling so these data do not reflect actual catch percentages of the overall species composition at Lake Oroville. Surveys were conducted in three areas of Lake Oroville that were selected on the basis of electrofishing suitability at various water levels, distance from launching facilities, and general representation of Lake Oroville littoral habitat. Total length was recorded for all fish sampled, and weights were recorded for fish greater than 100 mm.

The angler survey employed an access point design utilizing the primary boat ramps at Lake Oroville. Surveys were conducted on both weekdays and weekends from 1993 through 1999. All fish observed by survey personnel were identified to species, and most were measured (total length) and weighed. Data on released fish was recorded as a separate category, since the species identification and size approximations were based upon angler recollection, which can vary considerably.

In addition to this DFG study, DWR has conducted periodic fish sampling at Lake Oroville, using gill nets, midwater trawling, hook and line sampling, and direct observation.

4.2.2 Thermalito Diversion Pool and Thermalito Forebay

The Thermalito Diversion Pool and Thermalito Forebay are hydrologically connected by the Power Canal (refer to Description of Facilities section) with no barrier or fish screen between these two waters. This facilitates easy movement of fish from one reservoir to the other, particularly considering the large volumes of water that can be transferred back and forth, therefore a similar fish species composition should be expected.

The fish species composition listed in this report is based upon data collected from various evaluations since 1999, and includes boat electrofishing, gill nets, hook and line sampling, and an angler survey. Anecdotal information has also been gathered by DWR fisheries staff.

The Diversion Pool electrofishing data was based on two efforts, in June 1999 and June 2001, and the Forebay in October 1999. A Smith Root SR-18 electrofishing boat was used. Gill net and hook and line sampling was conducted for the *SP-W2 Contaminant Accumulation in Fish, Sediments, and the Aquatic Food Chain* during 2002 and 2003.

The Diversion Pool and Forebay angler survey employed a roving survey design (Malvestuto 1996) and was conducted from August 2000 through May 2003. Using stratified random sampling to select the days, surveys were conducted on one weekday and one weekend day from September 2000 through May 2003. All anglers were surveyed during the sample periods, and all fish observed were measured (total length).

5.0 STUDY RESULTS

5.1 LAKE OROVILLE

A comprehensive list of all the fish species currently known to exist in Lake Oroville is presented in Table 5.1.1. These species came to occur in the lake as a result of the impoundment of Feather River species captured when Oroville Dam was constructed in the early 1960s (e.g. rainbow trout, Chinook salmon, Sacramento pikeminnow, smallmouth bass, etc.), along with species that were intentionally introduced (e.g., brown trout, various strains of rainbow trout, Chinook salmon, largemouth bass, spotted bass), and unintentionally introduced (e.g., wakasagi). Illegal introductions have no doubt occurred as well. Movement of fish into Lake Oroville from the tributaries occurs on a regular basis (e.g. rainbow trout), and the potential exists for fish to be moved from the Diversion Pool into the lake via pump-back operations.

Table 5.1.1. Lake Oroville fish species composition.

Frequently Observed	***Infrequently Observed***
Chinook salmon (*Onhorhynchus tshawytscha*)	Brown trout (*Salmo trutta*)
Coho salmon (*Oncorhynchus kisutch*)	Rainbow trout (*Onchorhynchus mykiss*)
Largemouth bass (*Micropterus salmoides*)	Smallmouth bass (*Micropterus dolomieui*)
Redeye bass (*Micropterus coosae*)	Redear sunfish (*Lepomis microlophus*)
Spotted bass (*Micropterus punctulatus*)	White crappie (*Pomoxis annularis*)
Bluegill (*Lepomis macrochirus*)	Sacramento sucker (*Catostomus occidentalis*)
Green sunfish (*Lepomis cyanellus*)	Sacramento pikeminnow (*Ptychocheilus grandis*)
Black crappie (*Pomoxis nigromaculatus*)	Hardhead (*Mylopharodon conocephalus*)
Channel catfish (*Ictalurus punctatus*)	Threespine stickleback (*Gasterosteus aculeatus*)
White catfish (*Ictalurus catus*)	Sculpin (*Cottus spp.*)
Wakasagi (*Hypomesis nipponensis*)	Goldfish (*Carassius auratus*)
Common carp (*Cyprinus carpio*)	Threadfin shad (*Dorosoma petenense*)
	Golden shiner (*Notemigonus crysoleucus*)
Uncommon	**Historic**
White sturgeon (*Acipenser transmontanus*)	Kokanee salmon (*Oncorhynchus nerka*)
Lake trout (*Salvelinus namaycush*)	Sacramento perch (*Archolites interruptus*)
Warmouth (*Lepomis gulosus*)	Brook trout (*Salvelinus fontinalis*)
	Sacramento perch (Archolites interruptus)
	Various rainbow trout strains: Eagle Lake, Pit River, Coleman Kamloops

*It shoud be noted that 1 northern pike (*Esox lucius*) was reported caught by an angler in 1998, though this was not officially confirmed by DFG investigators*

As a result of the methods employed to collect the data used in this report, a determination of fish species distribution at Lake Oroville could not be ascertained. The angler survey was an “access point” survey where the data was collected as anglers returned to the boat ramps. This kind of survey does not provide for an accurate determination on where the fish were caught because anglers often fish various locations of the lake throughout the day, and would not normally be able to recall where each of their fish were caught. In regard to the electrofishing data, the survey locations were not randomly selected, rather they were selected to increase the likelihood of encountering larger numbers of fish in the limited timeframe provided.

Other than forage fish and carp, all of the “Frequently Observed” fish in Lake Oroville are game fish, with the black bass (*Micropterus spp.*) and coho salmon as the most common species. Relative percentages of the four different black bass species are presented in Table 5.1.2. In 2002, coho salmon replaced Chinook salmon and brown trout as the coldwater species that is stocked in the reservoir, in order to control disease outbreaks in the Feather River Hatchery downstream (DWR 2003). Therefore, the numbers of brown trout and Chinook salmon have recently dwindled while coho salmon numbers have increased.

Table 5.1.2. Lake Oroville black bass electrofish catch per 1000 seconds.

Year	Spotted Bass	Largemouth Bass	Redeye Bass	Smallmouth Bass
1994	56.36	11.47	3.81	4.03
1995	22.50	12.18	2.10	1.96
1996	33.33	5.10	3.05	0.45
1997	42.38	2.72	3.89	0.25
1998	46.79	5.12	2.89	0.17
1999	35.80	3.75	1.76	0.11
Average	**39.53**	**6.72**	**2.92**	**1.16**

Relative percentages of the salmonid species observed in the angler survey from 1993-1999 (prior to the recent coho stocking) are presented in Table 5.1.3.

Table 5.1.3. Lake Oroville salmonid catch from angler survey.

Year	Chinook Salmon	Brown Trout	Rainbow Trout	Total
93-94	1,492	99	7	1,598
94-95	672	70	6	748
95-96	2,229	227	29	2,485
96-97	649	22	16	687
97-98	645	2	9	656
98-99	556	6	11	573
Total	6243	426	78	6747
Percent	**92.5%**	**6.3%**	**1.2%**	

A summary of all Lake Oroville salmonid stocking is presented in Table 5.1.4.

Table 5.1.4. Lake Oroville salmonid stocking history.

	RBT	BN	CHIN	COHO	KOK	BKT / LT	TOTAL
1968	110,1922	93,035			60,000		**1,254,957**
1969	185,004	643,400		42,700			**871,104**
1970	31,200	101,600		60,900	164,200		**357,900**
1971	24,209	20,500		16,461			**61,170**
1972	89,006	31,230		89,556			**209,792**
1973	57,750	31,205		67,320	275,200		**431,475**
1974	40,705	15,000		37,500			**93,205**
1975	54,990	21,800		65,460	300,495	2,000	**444,745**
1976	40,101	18,400	48,280	67,510	230,000		**404,291**
1977	40,000	34,801		60,013	181,440		**316,254**
1978	140,000	27,000					**167,000**
1979	113,314	45,430	22,400				**181,144**
1980	278,180	20,650					**298,830**
1981	34,400	51,000					**85,400**
1982	40,484	37,400	100,225				**178,109**
1983	10,000	15,000	165,670				**190,670**
1984		57,700	125,410			54,255	**237,365**
1985		40,200	197,610	100,000		31,200	**369,010**
1986	7,400	65,920	43,250	130,000			**246,570**
1987		68,630		107,205			**175,835**
1988	221	44,200	55,040	38,500			**137,961**
1989		28,700	62,305				**91,005**
1990		57,400					**57,400**
1991		33,838	203,850	54,000			**291,688**
1992		68,956	122,980				**191,936**
1993		131,455	163,235				**294,690**
1994		50,004	159,610				**209,614**
1995		65,400	191,923				**257,323**
1996		88,602	256,276				**344,878**
1997		67,403	355,000				**422,403**
1998		55,000	459,133				**514,133**
1999		50,008	287,040				**337,048**
2000		155,700	28,600				**184,300**
2001							**0**
2002				178.529			**178,529**
2003				40,075			**40,075**
TOTAL	**2,288,886**	**2,336,567**	**3,047,837**	**1,155,729**	**1,211,335**	**87,455**	**10,127,809**

LEGEND
RBT = Rainbow Trout (Combination of all strains)
BN = Brown Trout (Combination of all strains)
CHIN = King Salmon (Chinook)
COHO = Silver Salmon (Coho)
KOK = Kokanee Salmon
BKT = Brook Trout (1975)
LT = Lake Trout (1984 & 1985)

5.2 THERMALITO DIVERSION POOL AND THERMALITO FOREBAY

A comprehensive list of all the fish species currently known to exist in the Thermalito Diversion Pool and Forebay is presented in Table 5.2.1.

Table 5.2.1. Forebay and Diversion Pool Fish Species Composition

FOREBAY	
Frequently Observed	**Infrequently Observed**
Rainbow trout (*Onchorhynchus mykiss*)	Largemouth bass (*Micropterus salmoides*)
Brook trout (*Salvelinus fontinalis*)	Bluegill (*Lepomis macrochirus*)
Sacramento sucker (*Catostomus occidentalis*)	Tule perch (*Hysterocarpus traski*)
Sacramento pikeminnow (*Ptychocheilus grandis*)	
Hardhead (*Mylopharodon conocephalus*)	
Sculpin (*Cottus spp.*)	
Common carp (*Cyprinus carpio*)	
Wakasagi (*Hypomesis nipponensis*)	
Uncommon	**Historic**
Striped bass (*Morone Saxatilis*)	Brown trout (*Salmo trutta*)
	Various rainbow trout strains: Eagle Lake, Pit River
Diversion Pool	
Frequently Observed	**Infrequently Observed**
Rainbow trout (*Onchorhynchus mykiss*)	Chinook salmon (*Onhorhynchus tshawytscha*)
Brook trout (*Salvelinus fontinalis*)	Largemouth bass (*Micropterus salmoides*)
Sacramento sucker (*Catostomus occidentalis*)	Smallmouth bass (*Micropterus dolomieui*)
Sacramento pikeminnow (*Ptychocheilus grandis*)	Bluegill (*Lepomis macrochirus*)
Hardhead (*Mylopharodon conocephalus*)	Black crappie (*Pomoxis nigromaculatus*)
Sculpin (*Cottus spp.*)	Common carp (*Cyprinus carpio*)
Wakasagi (*Hypomesis nipponensis*)	Golden shiner (*Notemigonus crysoleucus*)
	Tule perch (*Hysterocarpus traski*)
Uncommon	**Historic**
Striped bass (*Morone Saxatilis*)	Brown trout (*Salmo trutta*)
Coho salmon (*Oncorhynchus kisutch*)	

These species came to occur in the Forebay as a result of the impoundment of Feather River species captured when The Thermalito Diversion Dam was constructed in the 1960s (e.g., rainbow trout, Chinook salmon, Sacramento pikeminnow, smallmouth bass, etc.), along with species that were intentionally introduced (e.g., brown trout, various strains of rainbow trout, Chinook salmon), and unintentionally introduced (e.g., wakasagi). Illegal introductions have no doubt occurred as well. In addition, all species occurring in Lake Oroville could potentially exist in these waters from moving down through the powerplant and/or via the spillway during high water events. Anglers have reported higher numbers of brown trout and Chinook salmon in the Diversion Pool following prolonged spill events, something that did not occur during the sampling period of this analysis. Afterbay fish species could also be transferred into these waters via pump-back operations. Although the same relative frequency categories (“Frequently Observed,” etc.) were used as with the Lake Oroville fish species composition, it should be noted that a lower level of effort was expended in sampling these waters.

The most frequently observed fish are the rainbow and brook trout that are stocked in the Forebay on a regular basis, about 40,000 to 50,000 salmonids are stocked annually (Table 5.2.2) supporting a popular put-and-take fishery.

Table 5.2.2 Forebay fish stocking 1980 - 2001

Year	RBT	BKT	BN	CHIN	Total
1980	NO FISH STOCKED THIS YEAR				0
1981	38,347				38,347
1982	24,765			3,025	27,790
1983	34,922	22,750			57,672
1984	31,346				31,346
1985	58,405				58,405
1986	41,380				41,380
1987	127,435				127,435
1988	76,310				76,310
1989	54,548				54,548
1990	55,150				55,150
1991	54,440				54,440
1992	45,180				45,180
1993	32,190	14,640	7,400		54,230
1994	77,400	5,760			83,160
1995	40,240				40,240
1996	NO FISH STOCKED THIS YEAR				0
1997	29,300	10,660			39,960
1998	18,380	10,150			28,530
1999	28,450	9,740		25,000	63,190
2000	24,700	8,840			33,540
2001	22,400	8,600			31,000
	915,288	91,140	7,400	28,025	1,041,853

RT = Rainbow trout (Combination of all strains)
BN = Brown trout (Combination of all strains)
BKT = Brook trout
CHIN = Chinook salmon

The Forebay and Diversion Pool anglers target these fish, skewing the angler survey data toward these fish as shown in Table 5.2.3.

Table 5.2.3 Forebay and Diversion Pool Angler Survey Data.

Forebay

	# Days	# Anglers	Total Hrs	Fish < 15 IN (383 mm)								Fish ≥ 15 IN (383 mm)				
Year	Sampled	Contacted	Fished	RBT	BKT	CHIN	LMB	SB	SPM	SSU	CP	RBT	BKT	CHIN	COHO	SPM
2000	29	11	200	23	1	1	0	1	0	0	0	0	0	0	0	0
2001	100	134	2,035	653	44	0	0	0	1	0	1	11	1	0	0	1
2002	81	113	1,162	433	41	0	1	0	2	1	0	0	0	0	0	0
2003	22	9	425	138	1	0	0	0	0	0	0	0	0	0	0	0
Total	232	267	3,821	1,247	87	1	1	1	3	1	1	11	1	0	0	1

Diversion Pool

	# Days	# Anglers	Total Hrs	Fish < 15 IN (383 mm)								Fish ≥ 15 IN (383 mm)				
Year	Sampled	Contacted	Fished	RBT	BKT	CHIN	LMB	SB	SPM	SSU	CP	RBT	BKT	CHIN	COHO	SPM
2000	29	62	107	1	0	0	0	0	0	0	0	6	1	0	0	0
2001	100	100	184	3	0	0	0	0	1	0	0	1	1	1	0	0
2002	81	38	38	0	0	0	0	0	0	2	0	0	0	0	0	1
2003	22	13	12	0	0	0	0	0	1	0	0	0	0	0	1	0
Total	232	213	340	4	0	0	0	0	2	2	0	7	2	1	1	1

RBT = Rainbow trout	LMB = Largemouth bass	SSU = Sacramento sucker
BKT = Brook trout	SB = Striped bass	CP = Carp
CHIN = Chinook salmon	SPM = Sacramento pikeminnow	COHO = Coho salmon

Other (non-angler survey) fish sampling reflected a somewhat different fish assemblage, with Sacramento sucker and pikeminnow dominating the catch (Table 5.2.4).

Table 5.2.4. Forebay and Diversion Pool Fish Sampling, 1999-2003.

Forebay

Species	**E-fishing 10/19/99**	**Angling 07/18/92**	**Angling 7/19-20/92**	**Angling 6/11-12/92**	**Gill Net 04/15/03**	**Total**
Rainbow trout	3					3
Brook trout			1	1		2
Sacramento sucker	17	1			7	25
Sculpin spp.	5					5
Sacramento pikeminnow	2					2
Wakasagi	23					23
Carp		2			1	3
Tule perch					1	1
Total	50	3	1	1	9	64

Thermalito Diversion Pool

Species	**E-fishing 6/99 & 6/01**	**Angling 01/08/03**	**Angling 01/15/03**	**Total**
Rainbow trout	2			2
Brown trout	1			1
Brook Trout	2			2
Largemouth bass	1			1
Smallmouth bass	1			1
Sacramento sucker	20	4	2	26
Bluegill	9			9
Golden shiner	12			12
Hitch	1			1
Sculpin spp.	6			6
Sacramento pikeminnow	18			18
Wakasagi	2			2
Smallmouth bass	1			1
Tule perch	2			2
Black crappie	1			1
Hardhead	10			10
Total	**89**	**4**	**2**	**95**

6.0 ANALYSES

6.1 LAKE OROVILLE

Lake Oroville is managed as a two-story recreational fishery. A two-story fishery is comprised of both warmwater species that inhabit the warmer, littoral zone, and coldwater species that inhabit the deeper, cooler limnetic zone of the lake. The warmwater fishery, which is comprised of species such as spotted bass, largemouth bass, and catfish, is primarily sustained through natural reproduction in the lake. Supplementation of the largemouth population is periodically conducted by stocking Florida-strain largemouth bass, a fast growing strain of largemouth that achieves larger adult sizes. The coldwater fishery is almost entirely supported by hatchery stocking because insufficient habitat exists at Lake Oroville to support natural salmonid reproduction (Hiscox 1979). A small amount (less than 2%) of rainbow trout were recorded in the angler survey, these fish are not stocked in Lake Oroville but probably came from the lake's major tributaries where they are abundant. The primary forage fish, wakasagi, is also self-sustaining.

The dominance of game fish in the "Frequently Observed" category is typical of managed recreational fisheries, where angling regulations, fish stocking plans, habitat enhancement activities, and other management efforts are intended to maximize these game fish populations. In Lake Oroville, it is the salmonids and black bass that receive most of the management attention, angling for these fish represents one of the highest recreational uses at the lake and the high abundance of these fish indicates a successful management approach.

Because the salmonid fishery is primarily sustained by hatchery stocking, changes in stocking will drastically alter the make-up of the fishery, as seen with the recent switch to coho salmon from Chinook and brown trout. Stocking of Chinook and brown trout was suspended after 2000 in order to reduce the risk of transmitting Infectious Hematopoietic Necrosis Virus to the Feather River Hatchery (DWR 2003). For a decade, Chinook and brown trout were the primary coldwater fish caught in the lake, but by the summer of 2002, their numbers had diminished dramatically. The recently stocked coho (spring 2002) had not yet achieved a catchable size, so the overall coldwater fishing in Lake Oroville was poor However, by the end of 2002, the coho had grown large enough to be caught by Lake Oroville anglers, and the new coldwater species had taken over. Their rapid growth has continued throughout the spring of 2003, and coho as long as 20 inches (508 mm) had been caught by the end of May 2003.

Other than the Chinook and brown trout, the "Infrequently Observed" species list has not changed much since 1993, with the exception of threadfin shad. Numbers of threadfin shad, a forage fish, have dwindled since the early 1990s which may be a result of poor overwinter survival, or perhaps interspecific competition with wakasagi, Lake Oroville's primary forage fish. Threadfin used to be Lake Oroville's primary forage fish, but their presence diminished following the unintentional introduction of wakasagi in 1974. These fish likely came down the North Fork after being intentionally planted in Lake Almanor (Aasen 1998). Based on personal communication with DFG fishery biologists, smallmouth bass numbers have plummeted since the 1980s, probably as a result of competition and hybridization with spotted bass that were introduced in 1968, and again in 1980 and 1982.

A variety of fish have been stocked historically (over 10 years ago) in Lake Oroville, and most of them salmonids. Coho had been stocked periodically throughout the 1970s and 80s, as have kokanee salmon, brook trout, lake trout, various strains of brown trout such as the New York, Utah, Shasta, and Wyoming strains, and various rainbow strains such as the Mt. Whitney, Coleman Kamloops, Eagle Lake, and Pit River strains. Stocking changes were made for a variety of reasons including disease issues, cost, performance, angler desire, and experimentation.

The “Uncommon” category of fish in Lake Oroville is primarily based upon anecdotal reports from anglers. Lake trout have been reported caught as recently as 1998 (Lime Saddle Marina 1998), though these fish have never been recorded in the angler survey. Lake trout were stocked in the lake during the 1980s, and while it is possible that a small self-reproducing population may exist, it is more likely that these fish washed down from upstream waters where they are stocked on a regular basis, such as Bucks Lake in the North Fork Feather River drainage. Sturgeon periodically have been reported caught by anglers at the lake, but none have ever been observed by DWR or DFG fishery staff since the early 1990s. However, DWR fishery staff did observe a 3-4 ft. long sturgeon entangled in a gill net in the Spillway Cove in 2002, the fish was able to escape from the net prior to being measured and identified to species. White sturgeon were stocked in the lake in 1968 and again in 1988, this fish was likely a remnant from this stocking. Warmouth have been reported caught by anglers at the lake, but have never been observed by DWR or DFG fishery staff. They occurred in the Feather River prior to Oroville Dam (Dill and Cordone 1997), and are common in the Oroville Wildlife Area (DWR 2003b).

6.2 THERMALITO DIVERSION POOL AND THERMALITO FOREBAY

The Thermalito Diversion Pool and Thermalito Forebay are coldwater environments that receive most of their water from the cold depths of Lake Oroville on a year-round basis. The only other significant input of water comes from the Afterbay during pump-back operations, which can result in some degree of Forebay warming, though this is relatively short in duration and is mitigated by the Feather River Hatchery water temperature criteria. The water intake for the hatchery is located at the Thermalito Diversion Dam, so pump-back operations are halted if the water temperature at this site exceeds that which is needed at the hatchery.

As previously mentioned, no fish barrier exists between these water bodies and large amounts of water can be transferred between them, back and forth, in a relatively short time. Therefore it should be assumed that any fish species found present in one of these water bodies is likely to be found, at least to some degree, in the other.

Because of the coldwater nature of these reservoirs, their recreational fisheries are based around salmonids. No fish are stocked in the Diversion Pool, so its salmonid fishery is supplied by either Lake Oroville, or more commonly, the Thermalito Forebay. Although natural reproduction is possible in 1 or 2 small tributaries to the Diversion Pool, and brook trout are capable of spawning in lentic environments, no evidence has been collected that natural reproduction significantly contributes to the Diversion Pool fishery. No wild trout were observed in the creel survey or any other fish sampling conducted.

It should be noted that during 2003 a local angler reported seeing an adult rainbow trout in Glen Creek, an intermittent tributary. Backpack electrofishing was conducted in this stream during the late spring of 2003, but no salmonids were collected. Several remote ponds and backwaters occur along the margins of the Diversion Pool, and warmwater fish such as largemouth bass and bluegill do occur in these areas, though difficult access and small size limits their contribution to the Diversion Pool fishery.

The California Department of Fish and Game operates a put-and-take trout fishery at The Thermalito Forebay, where trout are stocked at a “catchable” size (~10-12 inches long), and most of these fish are harvested within a short time period. This requires frequent re-stocking to sustain the trout population, so the Forebay is stocked on a bi-weekly basis. Rainbow and brook trout are the only fish that have been stocked in the last few years, with rainbows comprising about 2/3 of the total. Very few trout (less than 1%) over 15 inches were recorded in the creel census at the Forebay indicating the short lifespan of the majority of these fish once planted. This is most likely due to high angler harvest, in fact DFG regularly achieves its goal to have at least 50% of these fish harvested by anglers (Meyer 1993). Another likely factor is mortality from ceratomyxosis, a naturally occurring disease caused by *Ceratomyxa shasta*, a myxosporean parasite that infects several species of salmonids including rainbow and brook trout (it is not harmful to humans). Fortunately a put-and-take rainbow and brook trout fishery is compatible with this disease since the majority of the fish are harvested before they succumb.

The Diversion Pool and Forebay perennial cold water temperatures provides a less complex reservoir habitat regime than Lake Oroville, resulting in a noticeably smaller and less diverse fish species composition. As with Lake Oroville, the game fish that reflect the fishery management activities in these waters are the most significant component of the “Frequently Observed” list. Rainbow and brook trout are stocked because they perform well in coldwater reservoirs, they are very popular with trout anglers, and are economical to raise at State fish hatcheries. The high angler returns at the Forebay have resulted in this fishery being one of the most popular catchable trout programs in Butte County. The much lower numbers of these fish observed in the Thermalito Diversion Pool is a result of no stocking occurring in the waters. However, the largest rainbow trout (approximately 10 pounds) observed at the Oroville Facilities' reservoirs in the last 10 years was caught in the Diversion Pool while electrofishing in June of 1999. This supports the frequent angler accounts of large trophy rainbow trout, brown trout, and Chinook salmon occurring in the Diversion Pool, particularly at the base of Oroville Dam where the Hyatt Powerplant tailrace enters, often carrying a supply of wounded or killed fish entrained through the powerplant from Lake Oroville. These angler accounts also suggest that the numbers of these fish are higher in the years following significant spills from Lake Oroville, something that did not occur during most of the time period when the data was collected for this report.

The "Infrequently Observed" list of fish in both of these waters is primarily comprised of those warm water game fish found in abundance in Lake Oroville and other waters of the Oroville Facilities, such as largemouth bass and bluegill, but their populations are restricted due to the lack of suitable (i.e. warm water) habitat in these reservoirs.

A noteworthy component of the "Uncommon" occurring species is the striped bass. Over the years, periodic angler accounts have reported striped bass being caught by trout anglers in the Forebay, and a striper estimated at 20 pounds was temporarily entangled in a gill net in 2002. Unfortunately the fish escaped from the net before it could be more accurately measured. Striped bass are not stocked in either of these waters, and they could not have migrated from the Feather River due to a variety of impassable dams. The most likely source for these fish is either an illegal introduction by anglers, or from the Thermalito Afterbay where striped bass were stocked in the 1980's. Although striped bass were not observed in the Afterbay during the data collection period for this report, it is possible that a small, self-sustaining population of these fish does exist. As previously explained, the Thermalito Pumping-Generating Plant can pump up to 9,120 cfs of water from the Afterbay into the Forebay, so it is possible that these fish, or their ancestors, were introduced in this manner. It should be noted that although water can be pumped from the Forebay (via the Thermalito Diversion Pool) into Lake Oroville, no striped bass has ever been recorded in Lake Oroville.

The "Historic" species list reflects the salmonids that have been stocked or are known to have existed in these waters, even though they were not recorded during the data collection period for this report.

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APPENDICES

Appendix A

Growth and Contribution to the Fishery of Chinook Salmon at Lake Oroville, California.

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GROWTH AND CONTRIBUTION TO THE FISHERY OF CHINOOK SALMON AT LAKE OROVILLE, CALIFORNIA

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ABSTRACT

Angler and fish population surveys and tagging studies were conducted at Lake Oroville from July 1993 through June 1999 to characterize the recreational fishery and evaluate the chinook salmon stocking program. Angler effort varied seasonally but was primarily directed at black bass (63%) or coldwater species (33%) of which spotted bass and chinook were the predominant species caught by anglers, respectively. Angler catch rates for salmonids varied seasonally but were >0.3 fish per hour in half of the 24 calendar quarters surveyed. Based on the number of effectively tagged chinook salmon released and recaptured, the salmon fishery is maintained by stocking. Chinook salmon stocked as fingerling-sized fish contributed to the fishery at a lower rate than yearling-sized fish and returned at a ratio of approximately one to five during most years of the study. Chinook salmon growth rates appeared to be related to chinook salmon densities and growth decreased as the number of salmon stocked increased. Chinook salmon reached or exceeded "target lengths" of 305 mm and 381 mm TL by age 18 months and 24 months, respectively, when 170,000 'yearling equivalents' or less were stocked. A 'yearling equivalent' was defined as the number of fingerlings and yearlings stocked in combination that would produce a similar angler catch if only yearlings are stocked and is based on return rates of CWT'ed chinook salmon in the recreational fishery. Most angler-caught salmon were three years of age or less. Trophy-size salmon were defined as fish greater than 5 pounds in weight and needed to exceeded approximately 610 mm TL based on length weight regression of angler-caught salmon from Lake Oroville. Few trophy-sized fish were observed at Lake Oroville. Chinook salmon in Lake Oroville were highly piscivorus and threadfin shad, wakasagi and unidentified fish remains comprised 89 percent of the stomach contents. Chinook salmon condition factors and prey abundance indexes did not appear to be related to stocking rates but condition factions were higher when the prey abundance index increased, although the relationship was not statistically significant. In 1994, higher than normal summer releases from the reservoir may have resulted in reduced survival or increased emigration from the reservoir based on poor angler returns of 1993 BY fingerlings. Extremely low returns of yearling chinook salmon and brown trout tagged with external reward tags suggested high tag shedding or high mortality of tagged fish. Based on analysis of information gathered, a maximum of 170,000 yearling chinook salmon or 'yearling equivalents' is recommended for annual stocking to maintain a quality salmonid fishery and provide for trophy fishing opportunities.

Black bass were the predominate warmwater species caught at Lake Oroville during the study. Fishing was considered good and angler catch rates exceeded 0.5 bass per hour

in all but one of the 24 calendar quarters surveyed. Spotted bass were the most abundant black bass species reported and observed caught during angler surveys and captured during electrofishing. Electrofishing catch rates for all black bass exceeded 40 fish per 1,000 seconds of pulsator output in all but one year and did not demonstrate any trends during the study. Smallmouth and largemouth bass electrofishing catch rates declined during the study but were not statistically significant. Spotted bass demonstrated good condition factors in all years and condition did not appear to be related to the prey abundance index. Condition factors for spotted bass 46 months of age and older were higher than for younger age groups of bass. There did not appear to be a relationship between chinook salmon stocking rates and black bass index of abundance, condition factor, or quality of the bass fishery.

INTRODUCTION

Lake Oroville is a large (6,400 HA) two story fluctuating reservoir in the northern Sierra Nevada foothills of California. Hiscox (1979) provided a physical description of the lake. The lake supports popular fisheries for both coldwater and warmwater gamefish. Threadfin shad were intentionally introduced to provide forage for gamefish in 1967. In 1975, wakasagi (pond smelt), *Hypomesis nipponensis*, were observed in Lake Oroville and are established in the lake. The fish most likely originated from an upstream source (Aasen et al, 1998).

In California waters where wakasagi are the principal forage, put-and-grow programs utilizing sub-catchable or catchable-sized rainbow trout have been largely unsuccessful. Lee (1980) reported that at Freshwater Lagoon, Humboldt County, only rainbow trout >279 mm fork length (FL) utilized pond smelt as forage. Rogers (1984) reported that pond smelt did not become an important part of the rainbow trout diet at Lake Shastina (Siskiyou County) until the trout exceeded 254 mm FL. In addition, the myxosporidian protozoan *Ceratomyxa shasta* is present in Lake Oroville. This organism causes serious losses in rainbow trout and no drugs or treatments for control are known.

The California Department of Fish and Game (CDFG) developed and instigated the Trophy Trout Program as a management strategy for large fluctuating reservoirs. Criteria for the Program were established but the objective of producing trophy-sized fish (fish ≥5 pounds) was not met (Rawstron 1973). In addition to trout, coho salmon *Oncorhynchus kisutch* have been successfully utilized in put-and-grow programs but are relatively expensive to produce due to a long rearing time in the hatchery (Rawstron 1975) . Brown trout *Salmo trutta* have been utilized at Lake Oroville, but returns of tagged fish in the past has been low suggesting that anglers do not catch a large percentage of the planted fish.

Chinook salmon *Oncorhynchus tshawytscha* were first stocked in a California reservoir in the early 1960's. The fish grew rapidly and reach sizes exceeding 15 pounds in three years (McAfee 1966) . Chinook salmon have demonstrated production advantages for California hatcheries, are able to utilize larger size prey, and are believed to be more limnetically oriented, allowing chinook salmon to more effectively exploit the wakasagi forage base. In addition, chinook salmon are a native species which historically occurred in the streams impounded by Oroville Dam. Although chinook salmon have been routinely stocked at Lake Oroville in the past, Chinook salmon have been used in managing California reservoir fisheries since the 1970's stocking rates have been based on those developed for other species.

Black bass are the most popular species in the warmwater fishery at Lake Oroville and have been managed with a 305 - 381 mm (12-15 inch) protected slot limit since 1983. Effects of the regulation on the fishery at Lake Oroville were evaluated by Lee et al (1992). Black bass tournaments have been held at the lake for a number of years and since 1998, the CDFG has issued exemptions to the slot limit regulation. Black bass angling interests have expressed concern over the potential effects of increased salmon stocking on the black bass fishery.

The purpose of this study was to determine appropriate chinook salmon stocking size and numbers needed to maintain a quality and trophy fisheries, and to continue data collection to evaluate the black bass fishery. This assessment of the Lake Oroville fishery was undertaken in cooperation and under contract with the reservoir operator, the California Department of Water Resources (CDWR).

METHODS

Recreational fishery surveys were conducted by stratified random sampling to obtain information on angler catch, harvest and use. Due to the physical characteristics of the reservoir an access point survey design was employed (Malvestuto 1983). All fish examined were identified to species and total length recorded. The number of hours fished, method of fishing, target species, angler origin, and other pertinent information was collected from each angler contacted. Weights were taken of a representative sample of salmonids examined. Data on fish reported caught and released was collected and classified by fish type ('black bass', 'salmonid', 'panfish', 'catfish', 'other') and by size class (< 305 mm, 305-381 mm, and > 381 mm). These 'small', 'medium', and 'large' size classes correspond to the black bass slot limit.

Surveys were conducted on both weekdays and weekends throughout the year. The majority of boat anglers utilized the ramp at the Oroville Dam spillway. The three other improved boat ramps were primarily used by recreational boaters and use of the five car top boat access points was typically low. Since recovery of tagged fish and collection of angler catch data were primary goals of this study, surveys were conducted to maximize contact with anglers. There was no effort made to estimate total angler use of the reservoir, but due to the limited shore and road access at Lake Oroville we feel that the majority of angling effort was assessed.

All chinook salmon planted in Lake Oroville from May 1993 through June 1998 were identified with coded wire tags (CWT's). Both tagged and untagged chinook salmon yearlings were released in November 1998 and tagged fingerlings were released in May 1999. The study plan called for an annual stocking of 100,000 fingerlings in the spring and a stepped increase in yearling numbers to be stocked in the fall of each study year.

In the spring of 1993, chinook salmon from the 1992 brood year (BY) were tagged at the Silverado Fisheries Base (Napa County) and the Merced River Fish Facility (Merced County). In subsequent years, all chinook salmon were tagged during the spring at the Feather River Hatchery or the Thermalito Annex Facility of the Feather River Hatchery, both in Butte County near the city of Oroville. Eggs from early fall run Feather River chinook salmon were used for all brood years except 1997. Adult early fall run 1997 BY Feather River salmon tested positive for infectious hematopoietic necrosis (IHN) and eggs taken at Iron Gate Hatchery (Klamath River stock) were used for the CDFG's inland chinook salmon program in calendar year 1998.

Chinook salmon examined by angler survey personnel were checked for the presence of CWT's and heads were removed from a sample of tagged salmon for recovery and identification of tags. All CWT's were processed at the CDFG Fisheries Programs Branch laboratory in Rancho Cordova. CWT's were decoded and numbers of fish and mean TL determined by month for each brood year and planting type (fingerling or yearling). For each BY the percent of the fingerling tag group caught was compared to the percent of yearling cohorts caught in order to develop relative return rates. Chinook salmon condition factors (K) were calculated from CWT return data. Stomachs were taken from a sub-sample of chinook salmon caught by anglers to evaluate prey species preference.

Approximately 400 yearling CWT chinook salmon were tagged with \$10 reward tags during each year of the stepped increases in yearling stocking. Additional 1993, 1995, and 1996 BY yearling chinook salmon and 1991 and 1993 BY catchable brown trout were tagged with \$10 reward tags. Reward tags were returned by anglers, catch data entered into the database, a letter of acknowledgment sent to the angler, and an authorization for reward payment forwarded to the CDFG fiscal section.

Hydroacoustic surveys were conducted monthly to characterize prey species abundance and distribution. Equipment included a Lowrance X-15 paper graph recorder operating at 192 kHz through a 20 degree cone angle transducer. Standard sampling protocols were established which included operating the echosounder at maximum sensitivity, surface interference suppression set at '2', chart speed adjusted to maximum, and the 'grayline' adjusted to achieve a clear bottom trace without introducing 'noise' onto the chart in the area of the water column. Boat speeds were kept to a minimum to eliminate interference from the boat's passage through the water. Due to the extreme depth of the main body of the lake (to 180 meters) a maximum recording depth was set on the sounding unit in order to achieve sufficiently detailed tracings of target fish. This depth was set to 30 or 45 meters depending on the distribution of target fish. Four transects were established utilizing landmarks which would be recognizable at all lake elevations and under most lighting and weather conditions. These transects crossed two of the inundated tributary canyons and the main body of the lake. Transects ranged in length from 1,370 meters to 4,160 meters and all transects were run consecutively during each sampling effort. Echosounder charts for each transect run were categorized by the relative number of traces (fish or schools) after Wilde and Paulson (1989).

Electrofishing surveys were conducted quarterly to collect species composition, size distribution and condition factor data for littoral species. Surveys were conducted using a Smith-Root SR-18 electrofishing boat, with one boat operator and two netters. All surveys were conducted at night.

RESULTS

Lake Oroville Fishery Evaluation

Angler interviews were conducted on a total of 893 days from July 1, 1993 through June 30, 1999. During this period 19,797 anglers were contacted who reported fishing a total of 113,670 hours (Table 1). Chinook salmon comprised 54.2 percent and spotted bass 27.9 percent of the 11,612 fish examined (Table 2). No other species made up more than 4.7 percent of fish examined. Angling effort varied seasonally but was primarily directed at either black bass (62.8 percent) or coldwater species (33.1 percent) with black bass percentage of effort increasing slightly and coldwater effort decreasing slightly during the study (Fig. 1).
Effort by other angling groups was highest during the second and third quarter of all years but was much lower than effort directed at coldwater species or black bass.

The black bass fishery is predominately 'catch-and-release' with less than seven percent of all black bass reported caught being kept. Anglers kept approximately 15 percent of black bass less than 305 mm and 11 percent of black bass over 381 mm (Table 3). Over 50 percent of the black bass reported caught were within the 305 to 381 mm protected slot and were thus illegal to keep. Coldwater anglers also demonstrated 'catch-and-release' angling and approximately one-third of all salmonids caught were reported to have been released. Interviewed anglers released roughly one half of sub-305 mm salmonids, one third of 305 - 381 mm salmonids, and one quarter of salmonids over 381 mm (Table 3).

The coldwater catch by size group varied seasonally with catch of large salmonids generally higher during the third quarter of the year and small salmonid catch higher during the fourth quarter following the stocking of yearling chinook salmon in the fall (Fig. 2). Black bass catch by size group was less variable. Overall black bass catch rates were generally lowest during the first quarter of the year (Fig. 3).

Chinook Salmon Growth and Fishery Contribution

A total of 1,582,622 chinook salmon was released in Lake Oroville from May, 1993 through June 30, 1999, including 1,371,901 effectively CWT"ed fish (Table 4). We recovered 2,037 CWT'ed chinook salmon from the fishery representing six brood years. For each BY of chinook salmon, the numbers of fish caught and mean total length (TL) were computed monthly for fingerlings, yearlings and both stocking sizes combined. Growth data was grouped quarterly for comparison of fishery contribution by individual BY's.

Growth of fingerling and yearling stocked CWT chinook salmon was compared by BY using computer generated power regression analysis (Lotus Development Corporation, 1994). For purposes of analysis, a TL of 60 mm was assigned to all BY's at two months of age. Growth was greater for fingerlings as compared to yearling chinook salmon for all brood years except 1993 (Fig. 4). Insufficient numbers of 1993 BY fingerlings were recovered for comparison.

Relative return rates for fingerling and yearling CWT'ed chinook salmon were determined for each BY by calculating the percent of available tags recovered (Table 5). Relative return rates were variable among years and ranged from 2.5 yearlings per fingerling return for the 1994 BY to 51.9 yearlings per fingerling return for the 1993 BY. Relative return rates were used to calculate a 'yearling equivalent' value for comparing stocking rates (Table 5). The 'yearling equivalent' describes fingerling and yearling combined returns as the number of yearlings alone required for an equivalent number of fish in the catch.

Chinook salmon growth rates decreased as numbers of fish stocked was increased (Table 6). Mean total length of recovered CWT chinook salmon at age 12 months and 24 months was generally greater when fewer fish were stocked.

Quarterly percent of catch by BY was computed to compare the relative contribution of stocking groups and age of fish at capture (Table 7).

Chinook salmon condition during the study period did not appear to be related to either fish age or stocking numbers (Table 8). Condition factors for Lake Oroville chinook salmon from September 1995 through June 1999 have varied seasonally but are consistently higher than those recorded for the period June 1993 through June 1995, in spite of greatly increased numbers of yearling chinook salmon planted in the fall from 1996 through 1998 (Table 8).

A total of 4,312 yearling chinook salmon was tagged and released with ten dollar ($10) reward Carlin tags (Table 9). First year exploitation, natural mortality and annual survival were calculated after Ricker (1958) and were adjusted to exclude out-of-basin recoveries and incomplete recovery information. Estimated first year chinook salmon exploitation ranged from < 0.01 for the 1996 BY to 0.09 for the 1994 BY. Estimated natural mortality for chinook salmon ranged from 0.66 for the 1995 BY to 0.94 for the 1994 BY. Mean annual survival calculated from reward tag recoveries was 0.14 for BY's 1992 through 1995. Tag return data is incomplete for the 1996 and 1997 BY's.

A total of 1,398 brown trout from two year classes was tagged with $10 reward tags (Table 10). Estimated first year brown trout exploitation was 0.05 for the 1992 BY and 0.03 for the 1994 BY. Estimated natural mortality was 0.95 for the 1992 BY and 0.66 for the 1994 BY. Annual survival estimated from reward tag returns was 0.00 for the 1992 BY and 0.31 for the 1994 BY.

Thirty-nine boat nights of sampling comprising 125,322 seconds of electroshock time were conducted between August 1994 and June 30, 1999. A total of 8,202 fish was identified to species, measured and weighed. Spotted bass were the most frequently caught species followed by bluegill and largemouth bass. Overall game fish catch rates (fish per 1,000 seconds of electrofishing effort) ranged from 39.53 for spotted bass to 0.03 for white crappie (Table 11). Catch rates were 1.90 for threadfin shad and 1.96 for pond smelt.

We used spotted bass as an indicator species for potential effects of chinook salmon stocking on warmwater fish populations. A total of 4,624 spotted bass was captured by electrofishing and measured. Of these 4,094 were large enough to weigh. Length-frequency distributions were determined for all quarterly samples to assign probable year classes to weighed fish. Spotted bass condition factors were calculated quarterly by brood year for fish age 12 months and over (Table 12). Spotted bass condition was lower than predicted for the 1994, 1996, 1997, and 1998 BY's ($t = 2.365$, $df = 7$, $P = 0.05$).

Stomachs were collected from 206 chinook salmon to determine prey species preference. Forty eight (23 percent) were empty. Total stomach contents by volume consisted of approximately 28 percent wakasagi, 29 percent threadfin shad and 32 percent unknown fish remains. Insect larvae and zooplankton made up a small percentage of stomach contents. We confirmed predation on wakasagi by chinook salmon as small as 240 mm TL. Prey species preference was variable with wakasagi tending to appear in chinook salmon stomachs at higher rates during the fall and winter and threadfin shad generally taken at higher rates during the spring (Fig. 5).

Monthly hydroacoustic survey data was grouped to develop quarterly abundance indices. Separate forage abundance indices were developed for each of three depth strata; 0 - 12 meters, 12 - 24 meters, and over 24 meters (Fig. 6). Forage abundance was more variable from July 1996 through June1999 than for the period from July 1994 through June 1996 (Fig. 6).

DISCUSSION

Length-weight data collected indicates that chinook salmon at Lake Oroville reach Trophy Trout Program criteria of 2.27 kg (5 pounds) or greater at a length of approximately 610 mm (Fig. 7) and at an age of forty-eight months or older (Fig. 8). Our results suggest that chinook salmon growth in the reservoir is inversely related to stocking density. To provide for the trophy trout fishery at the Lake Oroville and maintain a quality fishery, we set minimum growth standards for chinook salmon a minimum of 267 mm (10.5 in) mean TL at age 12 months, 330 mm (13 inches) at 18 months and 406 mm (16 inches) at 24 months.

Growth of the 1992 through 1996 BY chinook salmon at Lake Oroville was relatively consistent within each year class through age 24 months (Fig. 8). Growth in the third year of life was more variable and very few chinook salmon (0.25 percent in this study) in Lake Oroville survive past 36 months of age. In addition, recovered chinook salmon over 36 months were slow growing fish with a mean TL of only 500.4 mm.

Chinook salmon from the 1994 BY (yearling equivalent = 132,000) met all three of the above growth standards while the 1995 BY (yearling equivalent = 170,000) had adequate growth through 12 months but fell short of the 18 and 24 month standards (Table 5). The 1996 BY (yearling equivalent = 271,000) failed to meet any of the three standards and the 1997 BY (yearling equivalent = 422,000) failed to meet the 12 or 18 month standards. The 1997 BY is not yet 24 months old. Stocking levels for these four years by reservoir surface area are; 1994 BY = 20.6 fish per hectare, 1995 BY = 26.6 fish per hectare, 1996 BY = 42.3 fish per hectare, and 1997 BY = 65.9 fish per hectare (Table 5). The 1993 BY (yearling equivalent = 57,000) failed to achieve the 18 month standard but did reach the 24 month standard. This group of fish suffered very high losses in the hatchery due to bird predation and this growth pattern is perhaps a reflection of that stress.

Growth rates of chinook salmon stocked as fingerlings was higher than that of yearling cohorts. This may be due to improved growth in the lake environment or it may be an artifact caused by a higher mortality of smaller chinook salmon in the open lake than occurs in the hatchery. Because of this higher growth rate, fingerling stocked chinook salmon could make an important contribution to a trophy fishery.

The relatively high return of fingerling stocked chinook salmon during most years provides management with additional options for achieving desired fishery goals. The concept of a 'yearling equivalent' allows for the adjustment of stocking numbers in response to environmental conditions through consideration of factors such as predicted runoff and estimated reservoir releases. Because of the spawning time of chinook salmon, fingerling stocking numbers do not need to be finalized until late spring. By this time of year the CDWR has data on the state's snow pack and can estimate runoff and predict reservoir releases with considerable accuracy.

The poor fishery contribution of 1993 BY fingerling stocked chinook salmon may be the result of emigration of much of this group from the reservoir. Due to downstream temperature requirements for anadromous salmon, Lake Oroville releases were relatively high from June through October 1994, resulting in an elevation reduction of over 27 meters over this five month period (U.S. Geological Survey, 1995). It is possible that this flow carried a significant number of the recently planted chinook salmon fingerlings downstream.

Oroville dam releases are provided through a shutter system which is operated to provide optimal water temperatures for chinook salmon production at the Feather River Hatchery approximately eight miles downstream from the dam. It is likely that these temperatures are also optimal for the chinook salmon in the reservoir and releases would have been drawn from a stratum where reservoir chinook salmon were abundant. If such a dramatic summer reservoir draw down is predicted for a given year, fingerling stocking numbers could be reduced and these fish held for stocking as yearlings in the fall when reservoir releases are reduced.

As of June 30, 1999, anglers had reported catching nine reward tagged chinook salmon downstream from Lake Oroville. Three of these fish (all 1993 BY) were reported caught in the Pacific Ocean. Three (one 1992 BY and two 1993 BY) were reported caught in the Feather River downstream from Lake Oroville, two 1994 BY from the South Forebay north of the town

Table 6. Chinook salmon 'yearling equivalent' stocking rate and length at age by BY at Lake Oroville May 1993 through June 1999.

Brood year	Number of 'yearling equivalent' stocked	No. fish per HA	Mean total length @ 12 mo.	Mean total length @18 mo.	Mean total length @24 mo.
1992	77,000	12.0	276 mm	392 mm	489 mm
1993	57,000	8.9	280 mm	318 mm	421 mm
1994	132,000	20.6	275 mm	362 mm	436 mm
1995	170,000	26.4	273 mm	325 mm	401 mm
1996	271,000	42.3	256 mm	298 mm	385 mm
1997	(422,000)	(65.9)	240 mm	302 mm	N/A
Total	1,129,000				

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Table 1. Survey effort and estimated target angler catch rates for salmonids and black bass at Lake Oroville July 1993 through June 1999.

Year	Quarter	Number survey days	Number anglers contacted	Total hours fished	Total fish caught	Total fish kept	Total salmonids caught	Total bass caught	Total other caught	Coldwater hours fished	Bass hours fished	Salmonid catch per hour	Bass catch per hour
1993	3	36	826	4,567	2,280	497	163	1,826	291	853	2,343	0.19	0.78
	4	30	831	4,761	2,171	393	482	1,654	35	1,756	2,503	0.27	0.66
1994	1	27	1,236	7,396	2,042	864	1,143	898	1	4,080	2,907	0.28	0.31
	2	38	1,194	7,414	4,637	465	393	4,575	62	2,468	4,305	0.16	1.06
	3	33	826	4,734	2,795	731	413	2,336	46	1,341	2,502	0.31	0.93
	4	39	1,130	6,225	3,223	269	188	3,026	9	2,062	3,712	0.09	0.82
1995	1	38	1,293	7,710	3,209	478	471	2,737	1	2,598	4,774	0.18	0.57
	2	30	677	4,240	5,146	395	81	5,126	20	725	3,207	0.11	1.57
	3	38	694	3,798	2,665	541	342	2,276	47	889	2,452	0.38	0.93
	4	38	896	4,824	2,689	768	1,043	1,629	17	2,339	2,223	0.45	0.73
1996	1	40	1,185	6,790	3,801	1,472	1,921	1,878	2	3,444	3,215	0.56	0.58
	2	44	1,072	6,715	6,269	634	485	5,762	22	1,433	4,809	0.34	1.20
	3	41	717	4,114	3,235	747	629	2,592	14	1,403	2,398	0.45	1.08
	4	38	729	3,382	2,843	246	231	2,601	11	1,228	2,351	0.19	1.11
1997	1	43	851	4,665	1,998	109	13	1,984	1	675	3,854	0.02	0.51
	2	45	810	4,878	6,230	527	65	6,116	49	588	4,108	0.11	1.50
	3	39	553	3,021	2,687	386	79	2,582	26	526	2,290	0.15	1.13
	4	36	620	3,420	3,331	338	463	2,868	0	893	2,469	0.52	1.16
1998	1	43	929	5,470	3,581	236	471	3,110	0	1,203	4,146	0.39	0.75
	2	37	920	5,763	6,520	527	455	6,000	65	823	4,661	0.55	1.29
	3	32	312	1,861	1,289	185	250	1,020	19	401	1,177	0.62	0.87
	4	32	391	2,033	856	120	340	513	3	996	957	0.34	0.54
1999	1	34	563	3,067	1,489	181	304	1,185	0	909	2,045	0.33	0.58
	2	42	542	2,821	2,985	503	490	2,486	9	687	1,941	0.71	1.28
Totals/means		893	19,797	113,670	77,971	11,612	10,915	66,780	750	37,630	71,349	0.32	0.91

Table 2. Fish examined by species in Lake Oroville angler survey July 1993 through June 1999.

YEAR	CHIN	RT	BN	SPB	SMB	LMB	REB	PANF	CATF	TOTAL
93-94	1,492	7	99	313	104	33	3	40	39	2,130
94-95	672	6	70	756	160	98	27	31	35	1.855
95-96	2,229	29	227	621	126	39	76	38	14	3,399
96-97	649	16	22	633	26	63	186	26	11	1,632
97-98	645	9	2	631	10	28	133	65	17	1,540
98-99	556	11	6	259	4	18	68	19	12	953
Total	6,243	78	426	3,213	430	279	493	219	128	11,509
Percent	54.2	0.7	3.7	27.9	3.7	2.4	4.3	1.9	1.1	

Table 3. Salmonids and black bass kept and released by size group at Lake Oroville July 1993 through June 1999.

Size group	Number of fish kept	Number of fish released	Total	Percent of catch
		Salmonids		
< 305 mm	2,424 (48.3) *	2,594 (51.7)	5,018	45.9%
305 - 381 mm	2,222 (69.5)	975 (30.5)	3,197	29.3%
> 381 mm	2,100 (77.6)	605 (22.4)	2,705	24.8%
Subtotal	6,746	4,174	10,920	
		Black bass		
< 305 mm	2,601 (14.8)	14,941 (85.2)	17,542	26.4%
305 - 381 mm	473 (01.3)	35,923 (98.7)	36,396	54.8%
> 381 mm	1,353 (10.8)	11,154 (89.2)	12,507	18.8%
Subtotal	4,427	62,018	66,445	
Totals	11,173 (14.4)	66,192 (85.6)	77,365	

* Number in parenthesis is percent of total

Table 4. Numbers of coded wire tagged chinook salmon released and recovered at Lake Oroville May 1993 through June 1999.

Brood year	Total number fish released	Number effectively tagged fish released	Number of CWT salmon collected each year following release			Total
			Year 1	Year 2	Year 3	
1992	163,185	150,970	310	104	0	414
1993	159,600	141,882	139	51	0	190
1994	191,923	180,653	724	29	2	755
1995	256,276	237,301	167	125	(6)[1]	298
1996	355,495	324,922	196	(142)[1]	N/A	338
1997	456,143	336,173	(42)[1]	N/A	N/A	42
Totals	1,582,622	1,371,901	1,578	451	8	2,037

[1] Partial year (January through June) returns

Table 5. Numbers of CWT fingerling and yearling chinook salmon planted and recoveries by planting group at Lake Oroville, May 1993 through June 1999.

Brood year	Total Fish size	Number of number released	Total effectively tagged fish	Relative CWT recoveries	(%)	Approximate return — Year : Fing	'Yearling equivalent'
1992	Fing	102,585	96,430	91	(0.094)		
	Year	60,600	54,540	323	(0.592)	6.3 to 1	77,000
1993	Fing	104,400	89,166	6	(0.007)		
	Year	55,200	52,716	184	(0.349)	51.9 to 1	57,000
1994	Fing	101,922	97,743	245	(0.251)		
	Year	90,001	82,910	510	(0.615)	2.5 to 1	132,000
1995	Fing	105,841	98,750	34	(0.034)		
	Year	150,435	138,551	264	(0.191)	5.5 to 1	170,000
1996	Fing	105,267	96,214	26	(0.027)		
	Year	250,228	228,708	312	(0.136)	5.0 to 1	271,000
1997	Fing	106,143	102,534	(13)	(0.013)[1]		
	Year	350,000	233,639	(29)	(0.012)[1]	(1.0 to 1)	(422,000)
Totals	Fing	626,158	580,837	415			
	Year	956,464	791,064	1,622			
Grand total		1,582,622	1,371,901	2,037			

[1] 1997 BY returns available only through age 18 months.

Table 6. Chinook salmon 'yearling equivalent' stocking rate and length at age by BY at Lake Oroville May 1993 through June 1999.

Table 6. Chinook salmon 'yearling equivalent' stocking rate and length at age by BY at Lake Oroville May 1993 through June 1999.

Brood year	Number of 'yearling equivalent' stocked	No. fish per HA	Mean total length @ 12 mo.	Mean total length @18 mo.	Mean total length @24 mo.
1992	77,000	12.0	276 mm	392 mm	489 mm
1993	57,000	8.9	280 mm	318 mm	421 mm
1994	132,000	20.6	275 mm	362 mm	436 mm
1995	170,000	26.4	273 mm	325 mm	401 mm
1996	271,000	42.3	256 mm	298 mm	385 mm
1997	(422,000)	(65.9)	240 mm	302 mm	N/A
Total	1,129,000				

Table 7. Percent contribution of individual brood years to the salmon fishery at Lake Oroville July 1993 through June 1999.

	Calendar year						
Brood year	1993	1994	1995	1996	1997	1998	1999
Pre-1992	99.0%	58.3%					
1992	01.0%	41.4%	01.2%				
1993		03.0%	54.7%	02.7%			
1994			44.1%	93.5%	00.8%		
1995				03.8%	94.7%	26.5%	03.6%
1996					04.5%	68.4%	74.7%
1997						05.1%	21.7%

Table 8. Lake Oroville chinook salmon condition factor (K) by brood year.

	1992 BY		1993 BY		1994 BY		1995 BY		1996 BY		1997 BY	
Age in months	Mean TL[a]	K factor	Mean TL	K factor	Mean TL	K factor	Mean TL	K factor	Mean TL	K factor	Mean TL	K factor
13-15					318	0.99	270	0.92	277	1.07	287	0.98
16-18			290	0.74	349	0.96	310	0.91	283	1.02	303	0.98
19-21	470	0.79	412	1.10	381	1.07	327	1.04	344	1.00		
22-24	481	0.86	429	0.98	430	1.03	386	1.03	387	1.02		
25-27	511	0.88	484	0.92	430	0.97	414	1.02	422	0.91		
28-30	510	0.65	465	1.13	477	0.87	466	1.08	445	0.88		
31-33			597	1.10	443	0.94	554	1.23				
34-36			520	0.94	421	0.91	508	1.14				
Mean K		0.80		0.97		0.98		1.05		0.98		1.01

[a] TL is in mm.

Table 9. Catch, exploitation, natural mortality, and survival of Carlin tagged chinook salmon released at Lake Oroville 1993 through June 1999.

Brood year	Number of fish tagged	Number of tags returned Year 1	2	3	4	Total	First-year catch C1
1992	408	31	4	1	0	36	0.08
1993	793	76	8	0	1	85	0.10
1994	402	24	0	0	n/a	24	0.06
1995	1,300	6	3	n/a	n/a	9	0.00
1996	613	4	n/a			4	0.01
1997	796	n/a				n/a	n/a
Totals/means	4,312	141	15	1	1	158	0.04

Brood year	Number of tags removed	Number of tags in fishery	First-year exploitation u	Number fish kept	Natural mortality v	Annual survival s
1992	6	402	0.07	3	0.79	0.14
1993	13	780	0.09	76	0.82	0.10
1994	5	397	0.06	24	0.94	0.00
1995	8	1,292	0.00	6	0.66	0.33
1996	3	610	0.01	4	n/a	n/a
1997	0	796	0.00	n/a	n/a	n/a
Totals/means	35	4,279	0.04	141	0.80	0.14

Table 10. Catch, exploitation, natural mortality, and survival of Carlin tagged brown trout released at Lake Oroville 1993 through June 1999.

Brood year	Number of fish tagged	Number of tags returned Year 1	2	3	4	Total	First-year catch C1
1991	800	35	0	0	0	35	0.04
1993	598	18	8	0	0	26	0.03
Totals/means	1,398	53	8	0	0	61	0.04

Brood year	Number of tags removed	Number of tags in fishery	First-year exploitation u	Number fish kept	Natural mortality v	Annual survival s
1991	5	795	0.05	38	0.95	0.00
1993	6	592	0.09	23	0.66	0.31
Totals/means	35	1,387	0.04	61	0.81	0.15

Table 11. Electrofish catch per 1,000 seconds by species at Lake Oroville, August 1994 through June 1999.

	Effort	Species caught												
Year	(Sec.)	LMB	SMB	SPB	REB	BG	GSF	RSF	BCR	WCR	CCF	WCF	TFS	JPS
1994	18,134	11.47	4.03	56.36	3.81	20.29	0.22	0.00	0.17	0.06	0.50	0.06	5.68	0.11
1995	37,689	12.18	1.96	22.50	2.10	7.35	0.37	0.00	0.58	0.00	0.48	0.21	0.61	1.46
1996	20,013	5.10	0.45	33.33	3.05	16.64	0.70	0.05	0.05	0.00	0.55	0.05	2.65	1.90
1997	28,290	2.72	0.25	42.38	3.89	7.60	0.67	0.28	0.07	0.00	0.46	0.07	1.13	3.39
1998	12,118	5.12	0.17	46.79	2.89	10.07	1.65	0.00	0.00	0.00	0.58	0.00	1.32	2.89
1999	9,078	3.75	0.11	35.80	1.76	12.56	1.43	0.00	0.33	0.11	0.11	0.00	0.00	1.98
Mean catch		6.72	1.16	39.53	2.92	12.42	0.84	0.06	0.20	0.03	0.45	0.07	1.90	1.96

Table 12. Lake Oroville spotted bass condition factors by brood year.

Age in months	Brood year 91	92	93	94	95	96	97	98
13-15					1.27	1.30	1.27	1.21
16-18		1.33		1.30		1.11	1.18	
19-21			1.29	1.21		1.13		
22-24			1.35		1.19		1.28	
25-27				1.30	1.20	1.24	1.26	
28-30	1.36		1.24		1.17	1.21		
31-33		1.43	1.27	1.31	1.17			
34-36		1.39		1.34		1.38		
37-39			1.33	1.22	1.31	1.11		
40-42		1.30		1.18	1.24			
43-45	1.33	1.32		1.24				
46-48	1.46		1.45		1.43			
Mean K	1.38	1.35	1.32	1.26	1.27	1.21	1.25	1.21

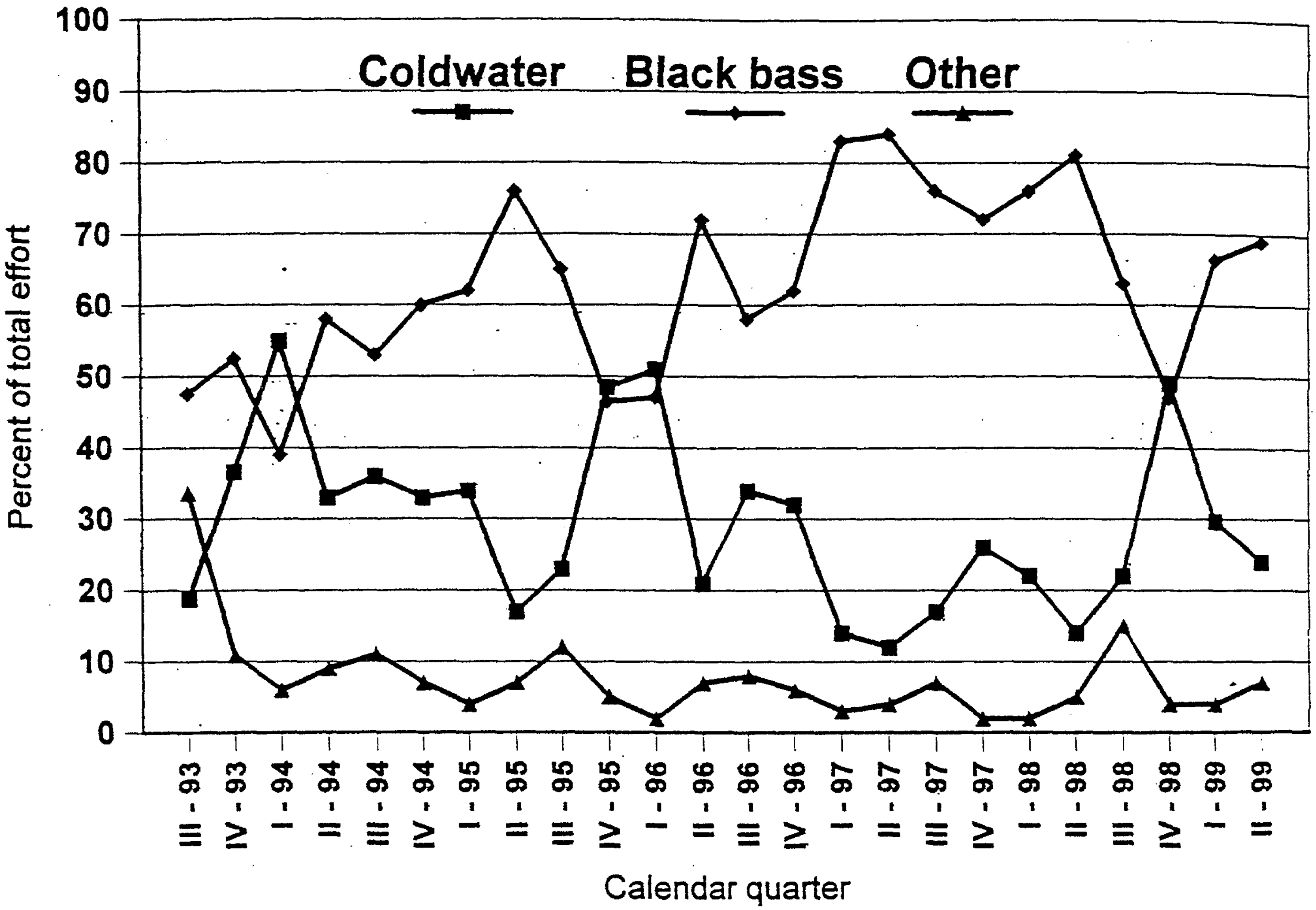

Figure 1. Angler effort by gear type at Lake Oroville, Jule 1993 through June 1999.

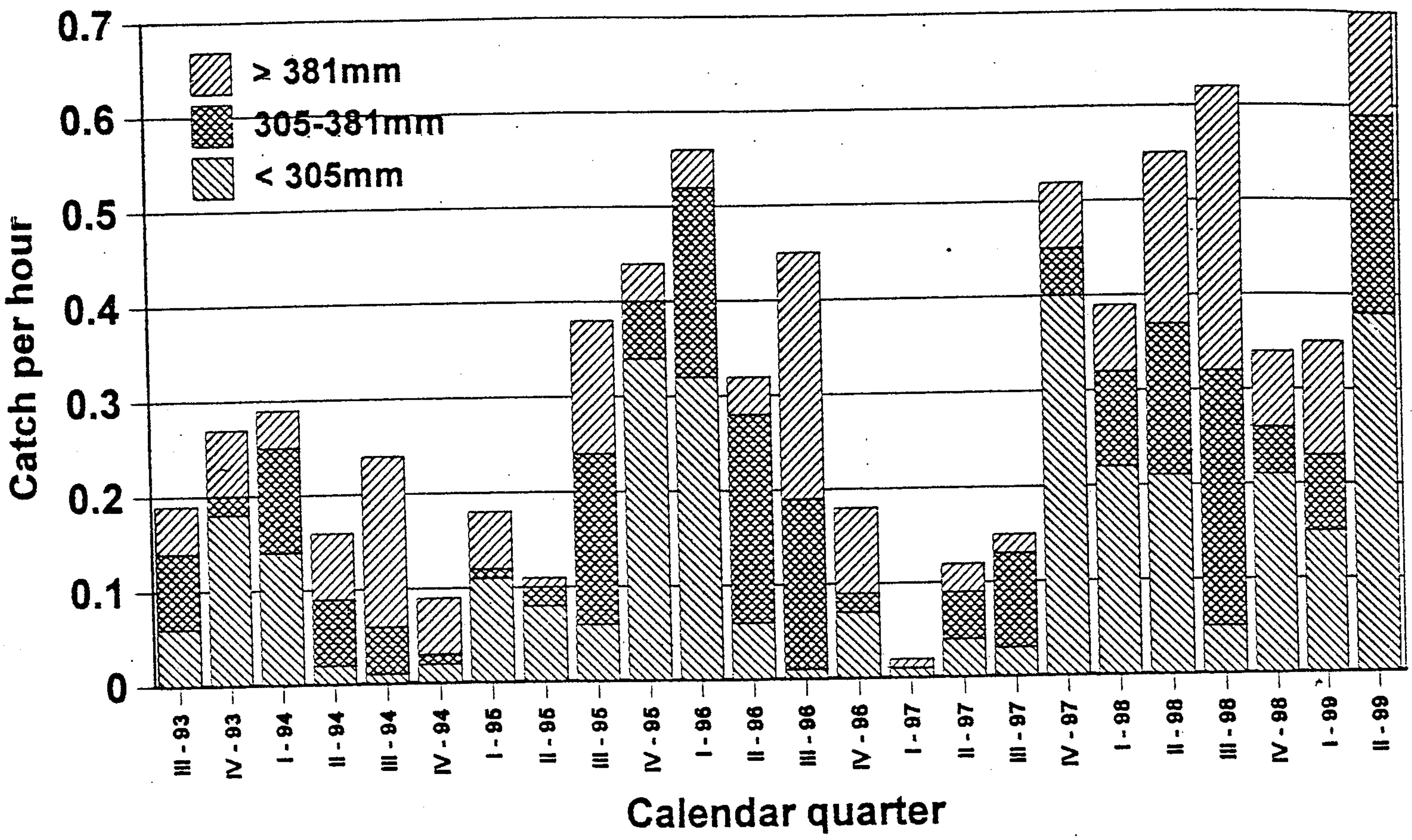

Figure 2. Salmonid catch per hour at Lake Oroville, July 1993 through June 1999.

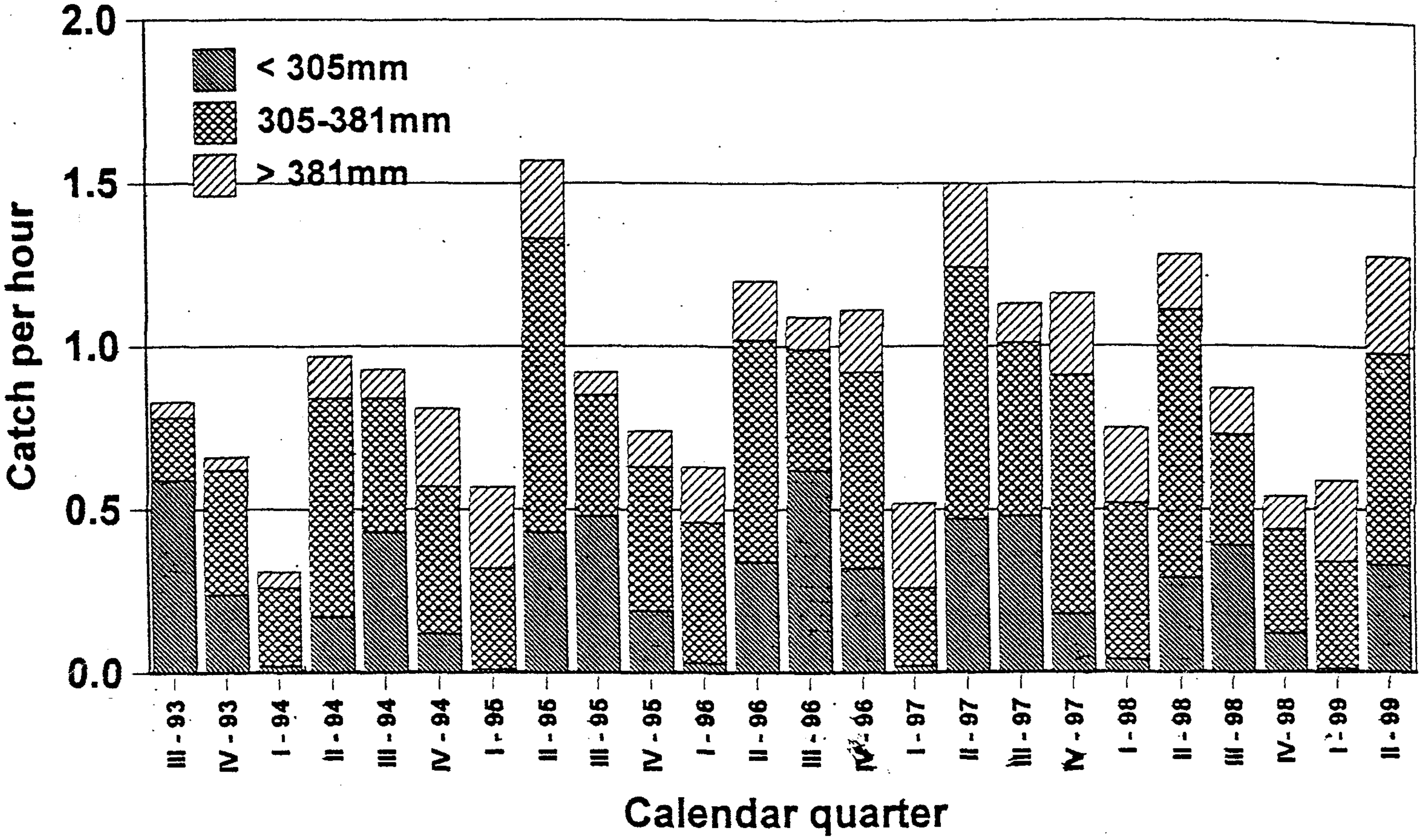

Figure 3. Quarterly black bass catch per hour rates for three size groups of fish at Lake Oroville, July 1993 through June 30, 1999.

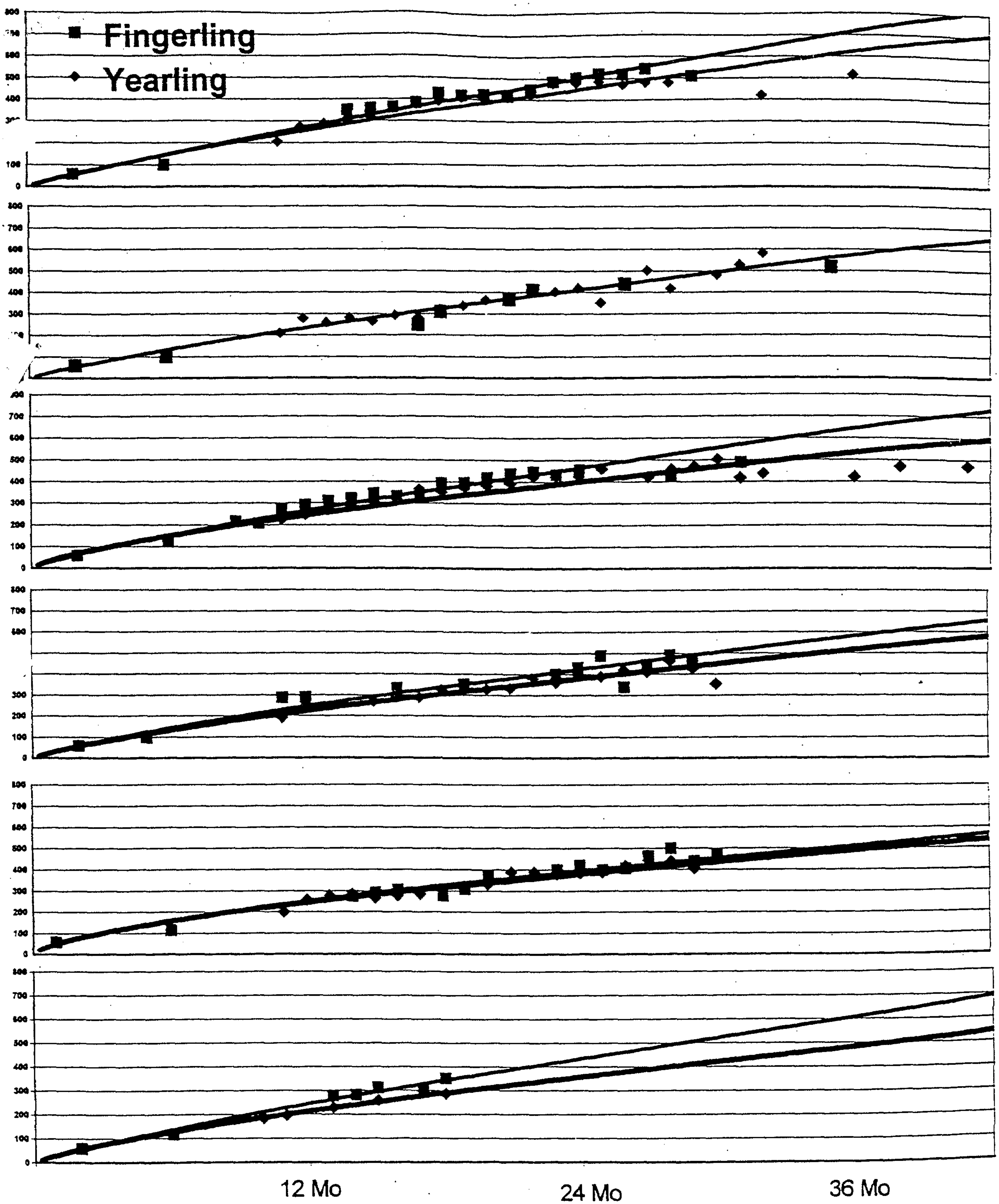

Figure 4. Mean total length at age of fingerling and yearling coded wire tagged chinook salmon from Lake Oroville, July 1993 though June 1999.

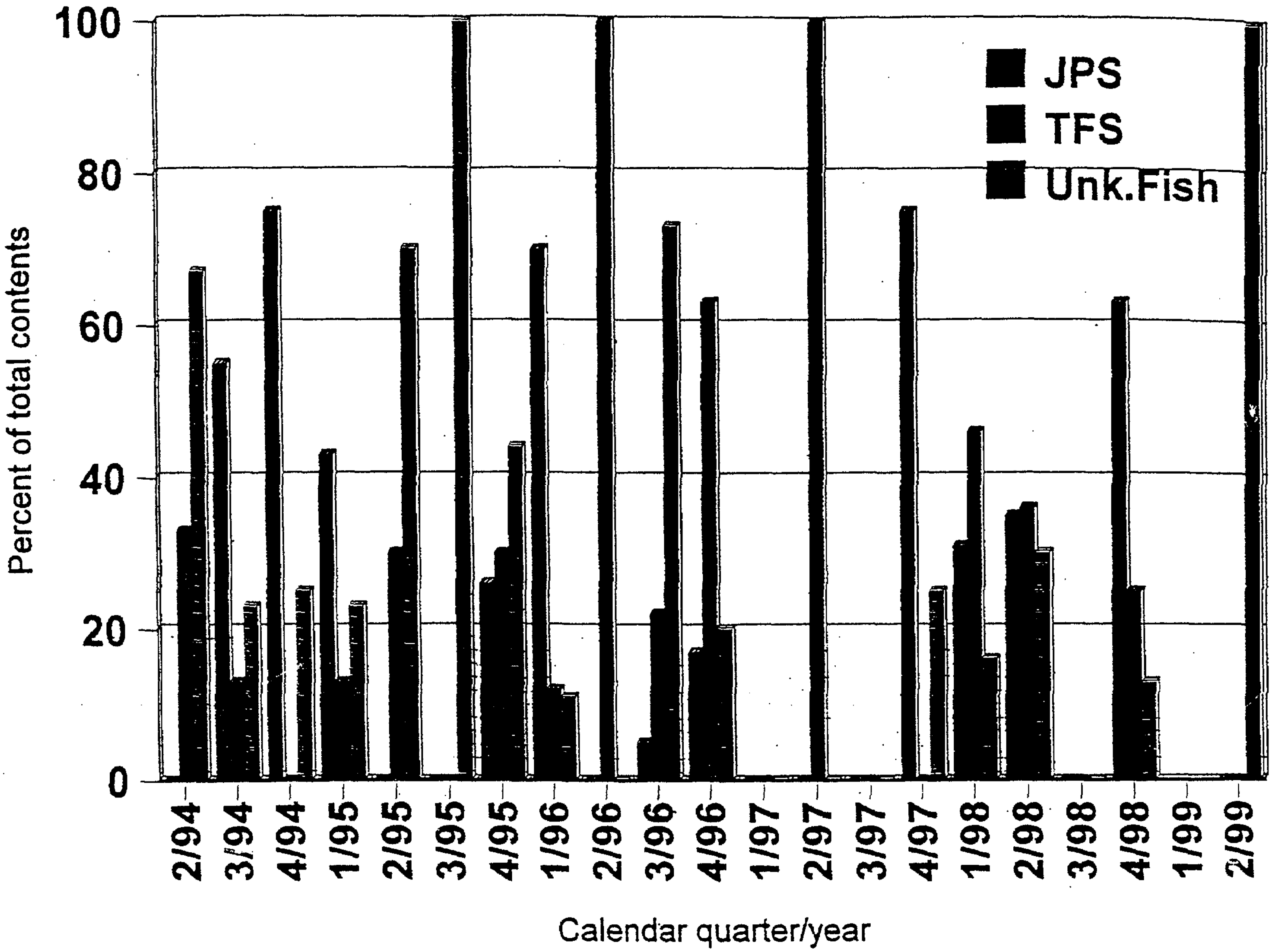

Figure 5. Chinook salmon stomach contents expressed as a percent of total composition collected at Lake Oroville, April 1994 through June 1999.

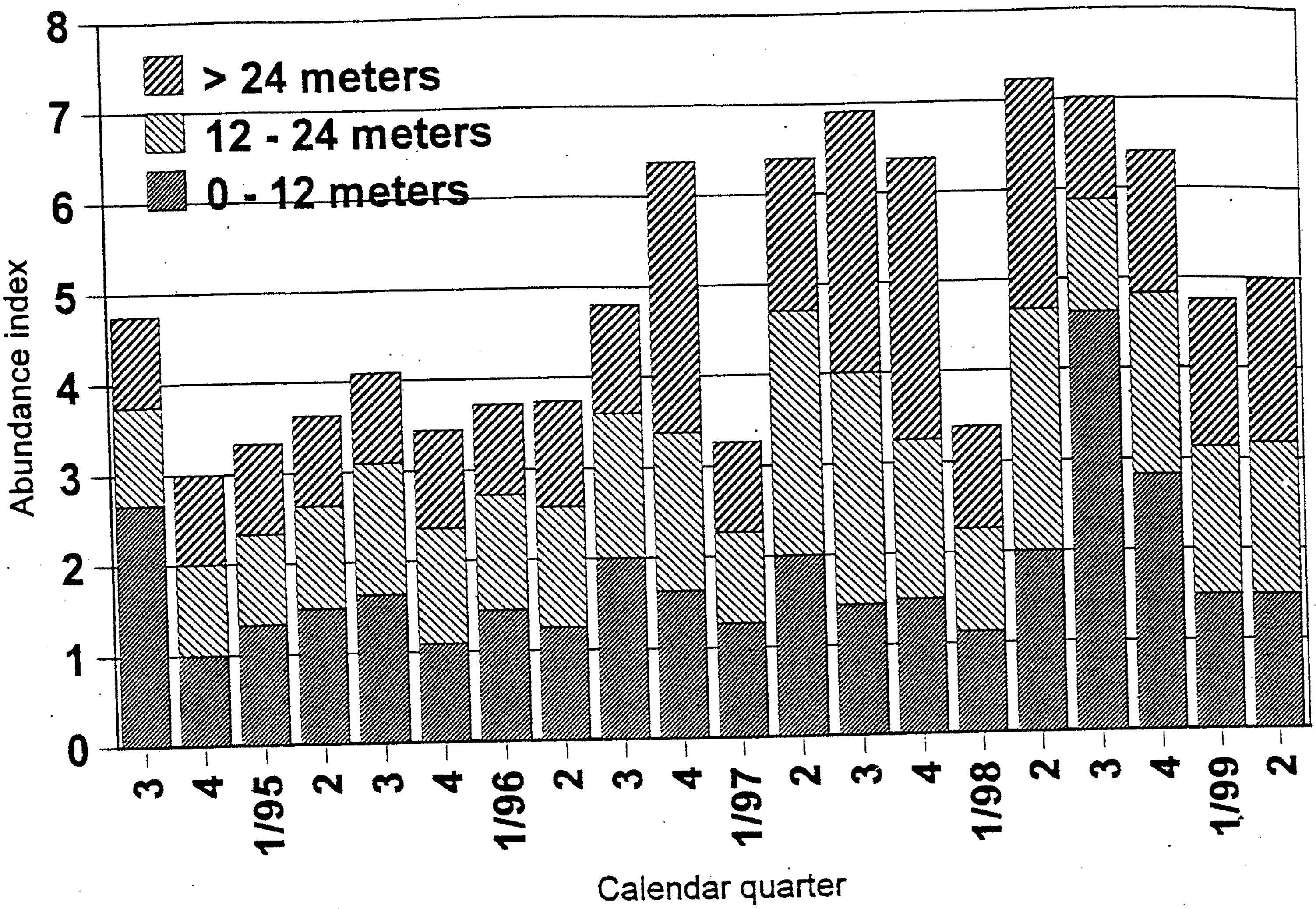

Figure 6. Index of forage abundance from hydroacoustic sampling, Lake Oroville, July 1995 through June 1999.

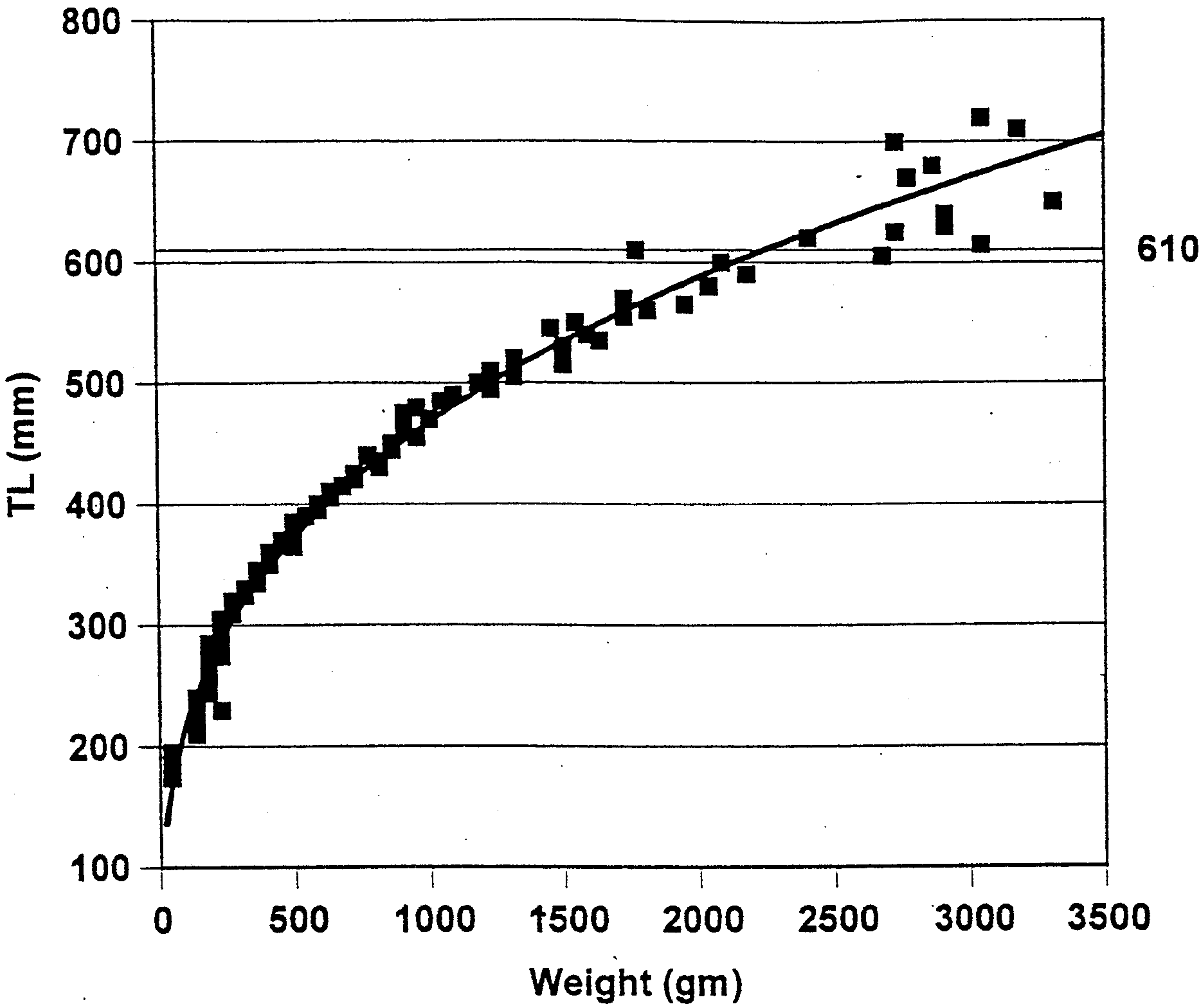

Figure 7. Length weight relationship of chinook salmon sampled at Lake Oroville, July 1993 through June 1999.

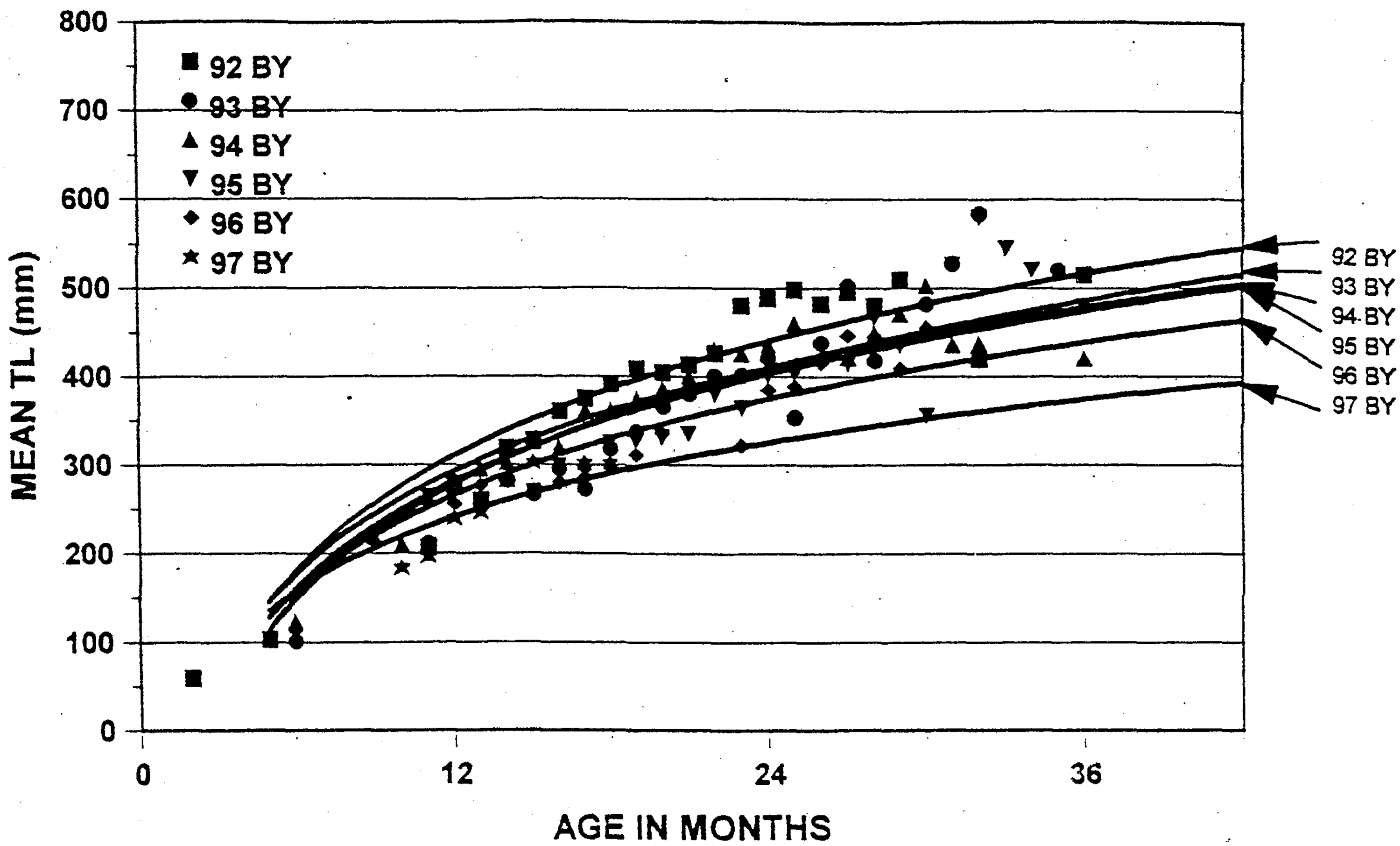

Figure 8. Mean total length at age of coded wire tagged chinook salmon collected at Lake Oroville, July 1993 through June 1999.

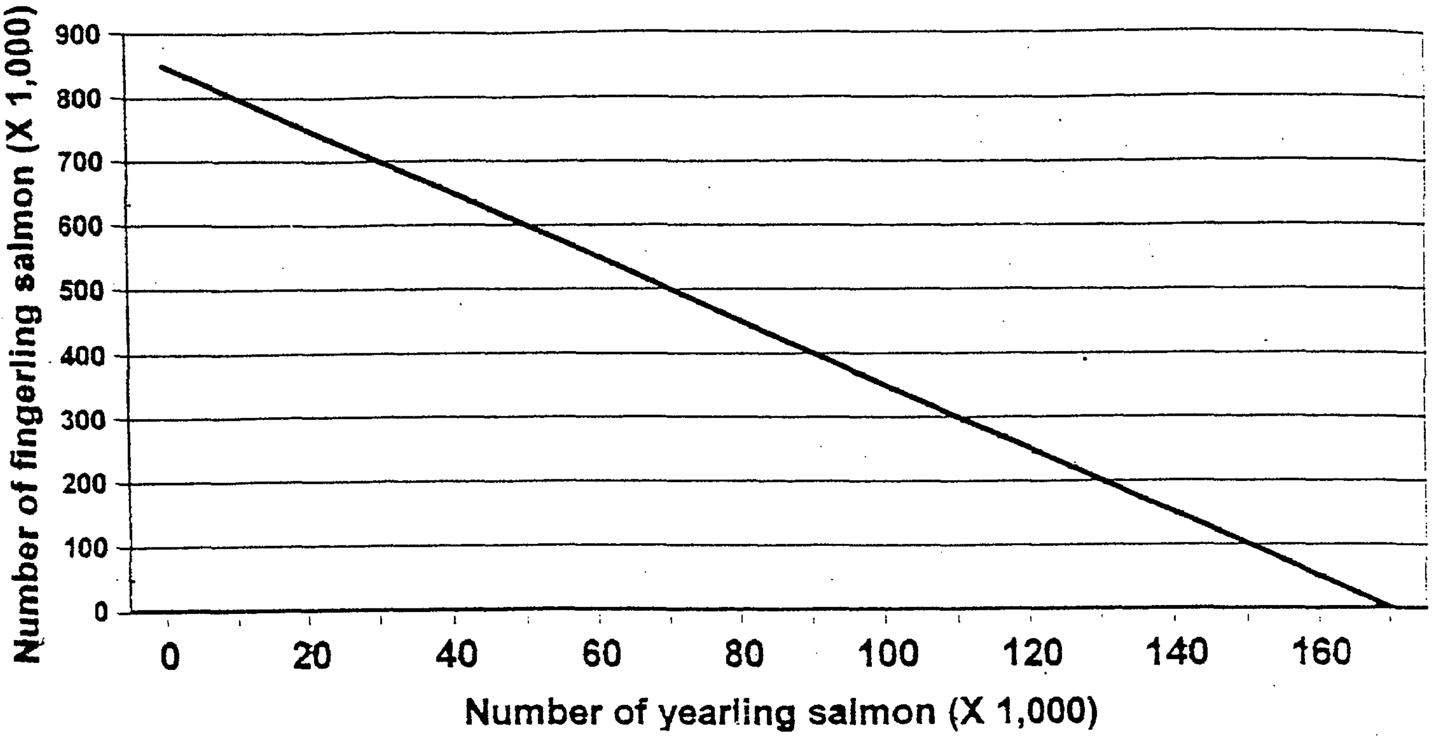

Figure 9. Recommended fingerling and yearling chinook salmon stocking numbers for Lake Oroville, Butte County.

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